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HANDICAPPED AND ELDERLY VERTICAL MOVEMENT ASSESSMENT STUDY

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FEBRUARY 1976

FINAL REPORT

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16. Abstract

This report discusses the selection and assessment of seven (7) types of vertical movement devices for potential use in older types of fixed rail urban mass transit facilities. The potential utilization of these devices is directed towards an increased usage of transit facilities by physically handicapped and elderly persons.

The study concentrates on the technical and cost considerations in the implementation and utilization of various standard (e.g., elevators, escalators, moving walks) and non-standard (e.g., inclined stairlifts, stair climbing wheel chairs) vertical movement devices in providing access and egress for elderly and handicapped persons to three (3) configurations of rapid-rail stations typically found in the older transit systems of the United States.

The stations surveyed presented three basic designs for traveller access. Each type of device was costed out for potential use in each station design. Cost comparisons showed that in a hypothetical situation the unit cost per device per installation per station indicated that the installation of non-standard devices represented a lower total cost. However, in a practical application, the actual situation is more complex. Station surveys indicated that some of the non-standard vertical movement devices could not be installed in stairwells or existing stations because of severe space limitations. In other instances, local or state safety ordinances and regulations would restrict the use of the non-standard devices in station stairwells.

The general conclusion reached in this study is that each station has its own unique character and unique access/egress problems which restrict or enhance the implementation of specific types of vertical movement devices. Hence, the determination of the device option which is technically most effective for a given station, must await the results of a detailed architectural study of the individual station under consideration.

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PREFACE

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1. INTRODUCTION

1.1 NATIONAL POLICY

Section 16 (a) of the Urban Mass Transportation Act of 1964, and related laws as amended through August 13, 1973, address the question of the planning and design of mass transportation facilities to meet special needs of the elderly and the handicapped. Section 16 (a) states that:

> "It is hereby declared to be the national policy that elderly and handicapped persons have the same right as other persons to utilize mass transportation facilities and services; special efforts shall be made in the planning and design of the mass transportation facilities and services so that the availability to the elderly and handicapped persons of mass transportation which they can effectively utilize will be assured; and that all federal programs offering assistance in the field of mass transportation (including the programs under this Act) shall contain provisions implementing this policy."

Subsequently, Section 16 (d) of this same legislation defines handicapping conditions as follows:

> "For purposes of this Act, the term 'handicapped persons' means any individual who, by reason of illness, injury, age, congenital malfunction, or other permanent or temporary incapacity or disability, is unable without special facilities or special planning or design to utilize mass transportation facilities and services as effectively as persons who are not so affected."

The language of this legislated policy is both broad and comprehensive, and its implementation poses certain problems. First, the definition of "handicapped person" is so all encompassing, and, second, existing capital investment in terminal facilities and vehicular equipment is large and so far unable to accommodate the needs of all the handicapped as defined by this legislation.

This report addresses both the breadth of the "handicappped" definition and the inadequacies of contemporary facilities. The report has the narrow goal of identifying the most limiting

obstructions to urban mass transportation access for the elderly and the physically handicapped. It offers recommendations as to how such barriers might be removed in existing fixed rail urban transit systems.

1.2 MARKET SIZE

As part of this study, a survey was conducted of the most significant documents generated during the last decade addressing the question of the size of the population of the physically handicapped and elderly in the United States who might benefit by enhanced access to urban mass transportation. On the basis of this survey, and the correlation of published estimates with more detailed information on specific disability components of the handicapped population derived from other sources, it would appear that the data published by UMTA and TSC in July, 1973, in a report entitled "The Handicapped and the Elderly Market for Urban Mass Transit" provides the best current estimate of the size of this population grouping. Table 1-1, taken from that report provides an overview of handicapped and elderly statistics. Table 1-2 taken from that same report gives a breakdown of the numbers of handicapped with transportation dysfunctions nationally, including both the elderly and the non-elderly handicapped.

1.3 APPROACH

The approach used in this study is as follows. Subcategories of the handicapped were related to travel restrictions inherent in existing rail transit systems. This required a translation of medical classifications of disease or trauma into functional limitations on the mobility of the affected humans. These functional limitations were then used to identify static and dynamic characteristics of transit terminals and transportation vehicles which prevent access or reduce the utility of urban mass transport to the physically handicapped and elderly.

A review was conducted of existing facility and vehicular problems which restricted travel by physically handicapped and elderly persons in order to identify specific travel barriers. Consideration of these travel barriers developed correlations between

TABLE 1-1 OVERVIEW OF HANDICAPPED AND ELDERLY STATISTICS

Total Elderly		20,100,000
Total Handicapped		13,390,000
BUT THERE ARE SIGNIFICANT OVERLAPS		
Elderly & Handicapped Total (with no double counting)		26,500,000
THIS BREAKS DOWN TO THREE RELEVANT MUTUALLY EXCLUSIVE CLASSES:		
Handicapped	Elderly	6,990,000
	Non-Elderly	6,400,000
Elderly who are not Handicapped		13,110,000
	GRAND TOTAL	26,500,000

TABLE 1-2 1970 ESTIMATES OF THE NUMBER OF ELDERLY AND NON-ELDERLY HANDICAPPED PERSONS IN THE UNITED STATES BY HANDICAP CLASS

Handicapped Class	Elderly Handicapped	Non-Elderly Handicapped	Total Handicapped
Visual Impairment	1,430,000	540,000	1,970,000
Hearing Impairment	160,000	190,000	350,000
Wheelchair	230,000	200,000	430,000
Walker	350,000	60,000	410,000
Other Special Aids	2,280,000	3,210,000	5,490,000
Other Mobility Limitations	1,510 000	1,800,000	3,310,000
Temporary Acute Conditions	100,000	370,000	470,000
Institutionalized	930,000	30,000	960,000
TOTALS	6,990,000	6,400,000	13,390,000

Source: HEW National Center for Health Statistics
1970 Census of Population

specific handicapping conditions and particular structural aspects of terminals or equipment ranging from minor inconvenience to total and absolute exclusion from the system.

The study concentrated on features of the travel environment which represent the greatest exclusionary limitations. This identification takes into consideration the current state of typical mass transportation systems and stresses those barriers which represent both great impediments to the travel of the physically handicapped and elderly and for which the capital costs of barrier elimination are relatively high. Thus architectural features of terminals, initially expensive and with lifetimes extending into decades, were considered more likely candidates for consideration than the lower per-unit-capital costs and shorter amortization times of rolling stock.

Vertical movement has been identified in earlier studies as the primary travel barrier to the handicapped and elderly (H&E) population. (See Section 3.2.) Technological approaches which could either eliminate this impediment or make it more manageable by the handicapped and elderly traveler were evaluated during the course of this study.

2. DYSFUNCTION DEFINITION

For the planner or designer considering new facilities or retrofitting old facilities to make them accessible to the physically handicapped and elderly, demographic data expressed in medical terms must be transformed into human mobility limitations germane to transit facilities and vehicles. Figure 2-1 is a comprehensive attempt to make explicit the process of achieving this transformation. The figure was derived from both medical records and surveys of people with different physical disabilities.

Human disability data are usually collected in the general dysfunction categories shown in column one of Figure 2-1 (e.g,, neuro-muscular, orthopedic, etc.) and in terms of the prevalent disabling disease, as listed in column 2 (e.g., cerebral-vascular, polio, arthritis, aging, etc.). These medical etiologies are recast in column 3 into "Defined Disability" and thence into the "Generalized Disabling Symptoms" of column 4. This permits subdividing the population of interest into the major classifications of semi-ambulant, non-ambulant, and ambulant. See Column 5.

The non-ambulant classification includes those persons capable of independent travel, but requiring a wheelchair or in extreme cases, stretcher-borne. In the second classification, the semi-ambulant, mobility is aided by devices, such as canes, walking sticks, braces, crutches, artificial legs, wheeled frames, and walkers. The third category of the handicapped is the ambulent who suffers sensory losses, particularly blindness and/or deafness, as well as the ataxic whose loss of, or diminished exterio-receptive senses, complicates or inhibits their use of mass transit. Special types of ambulants would include these, for example, employing artifical upper limbs who find certain aspects of the transit system limiting.

The human dysfunctional classifications (Column 5) in combination with the appropriate "Mobility Aid Device(s)" (Column 6) leads to the set of "functionally limiting physical capacities" of

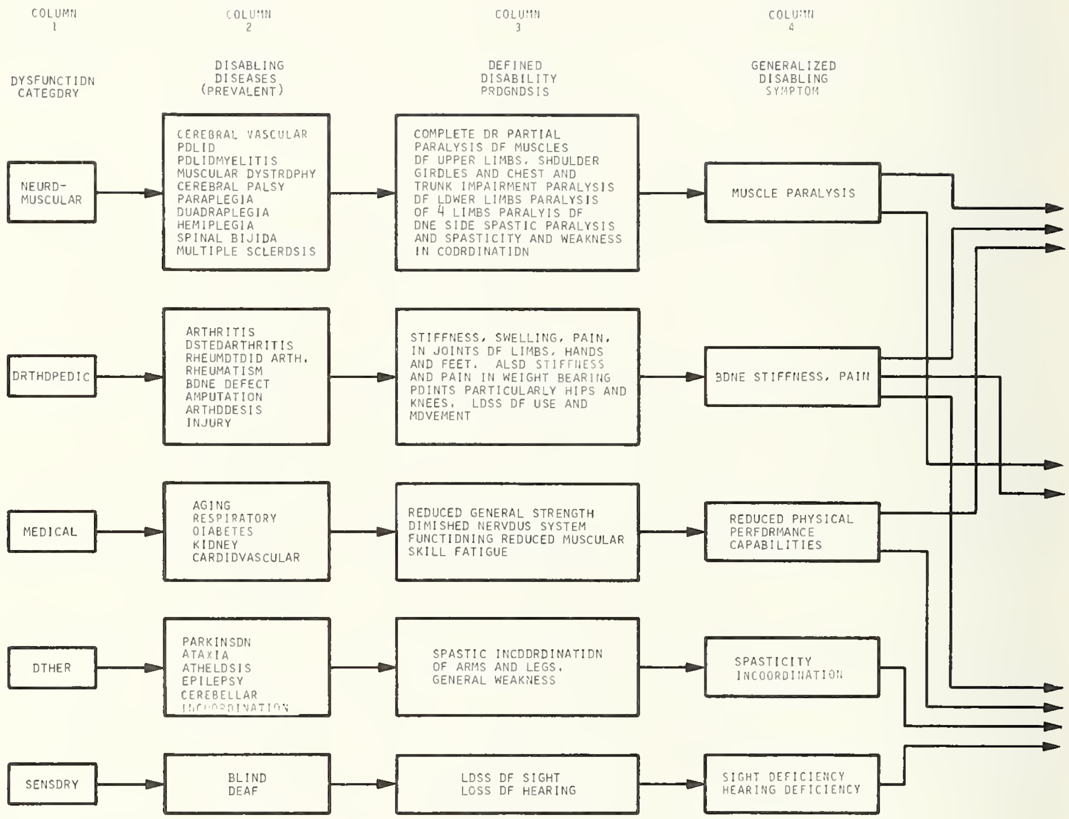

Figure 2-1 Spectrum of Human Performance Measures of the Handicapped and the Elderly

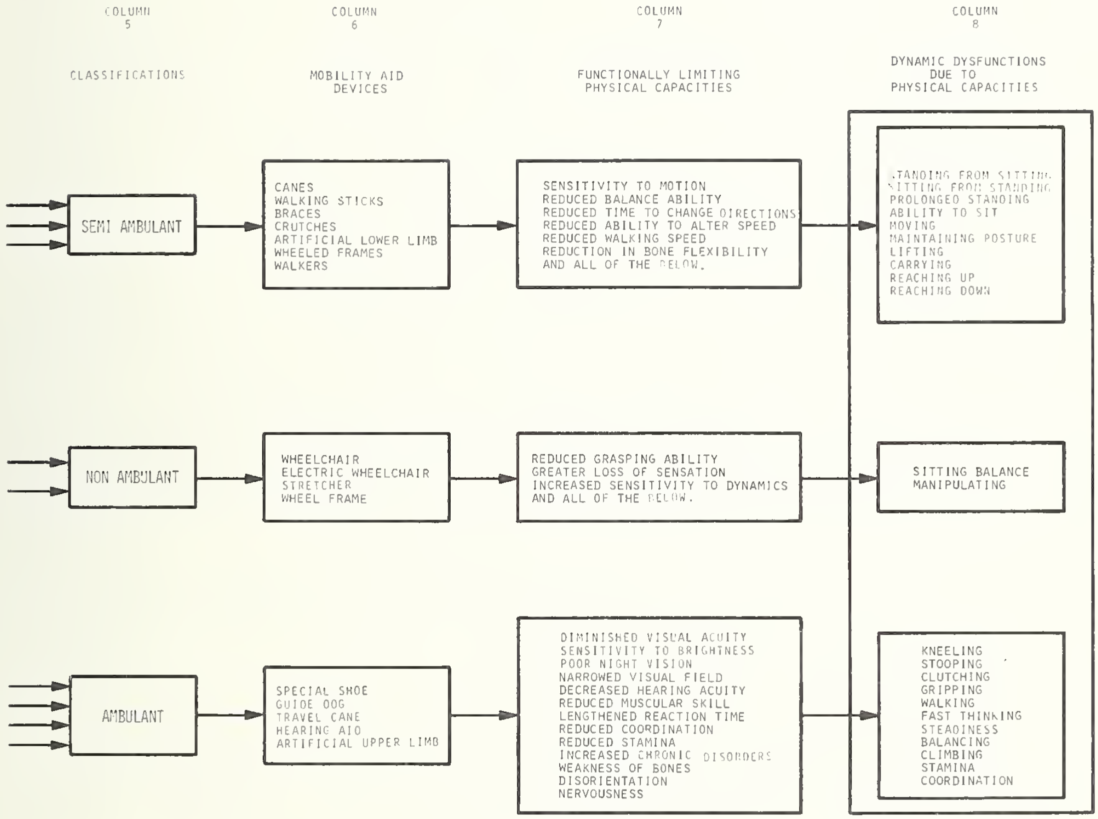

Figure 2-1 (Continued)

Column 7. These capacity sets are defined in terms of depreciated strength, motion, balance, energy, coordination, acuity, orientation, etc. Finally, these "Functionally limiting physical capacities" are related to "dynamic dysfunctions due to physical incapacities" in Column 8 in terms pertinent to travel barriers inherent in mass transit.

Ultimately, these transit-related dysfunctions due to physical capacities listed in the last column of Figure 2-1 must be expressed in quantitative terms. The combination of such specifications and current demographic data on the numbers of individuals affected by each of the dysfunctions would then provide the transit planner or designer with the explicit information necessary to define, order and optimize those revisions to a transit system required to provide cost-effective access to the transit system for the physically handicapped and elderly. Demographic instruments, such as the Bureau of Census data and Public Health Surveys, should be refined, utilizing an approach similar to that depicted in Figure 2-1, so as to develop a reliable, comprehensive tool for more precisely determining the size of the physically handicapped and elderly population of the United States.

A hazard in establishing these necessarily oversimplified dysfunction compartments is that more often than not, individuals affected by one limitation are also subject to another, or some combination of, physiological limitations. Further, the psychological burden imposed by such limitations when the person enters the travel environment can have the practical effect of generating dysfunctional limitations not exclusively physiological.

3. BARRIER IDENTIFICATION

3.1 GENERAL

Handicapped rail transit passengers encounter numerous problems inherent in large mass transportation systems, even when traveling with the assistance of a suitable mobility aid device. The most severe problems occur at the interface between the environment and a transit terminal and/or transit vehicle.

The principal problems are characterized by movement limitations and may be divided into problems of distance (spatial) and problems of movement discontinuities (dynamical). Obstructions to movement occur in both vertical and horizontal travel and can pose different degrees of exclusion ranging from absolute to partial to none at all. As an example of an absolute exclusion, the wheelchair traveler is precluded access to the terminal by a subway stairway. That same stairway could cause partial exclusion to a semi-ambulatory traveler by forcing the expenditure of abnormal amounts of time or energy. Note that for many semi-ambulatory travelers, the combination of a succession of partial impediments can lead to absolute exclusion when the physiological burden of travel does not warrant the benefits to be derived from use of the system.

Movement problems occur at various discontinuities in the travel regimen. For fare collection, station design deliberately channels pedestrian travel into passageways as narrow as 18 inches. The resulting maze proves incompatible with wheelchair dimensions. Even the semi-ambulant can be confronted with an absolute exclusion due to the inpassability of a turnstyle. Another travel barrier is the gap between the transit platform and the transit vehicle which can range from 2-1/2 to 5 inches. Whether or not such a gap represents an absolute or a partial exclusion would again depend upon the traveler. It might prove impossible for certain wheelchair travelers; though a real hazard, it might be passable for certain blind travelers.

Once within the transit vehicle, new mobility problems present themselves to the handicapped patron. Information flow is further reduced or totally eliminated for certain classes of sensory impaired persons.

Physical accommodations--seating, handholds, etc.--can produce absolute exclusion for the wheelchair traveler with no physical place to accommodate his wheelchair. These same hardware arrangements can effectively exclude the semi-ambulatory person incapable of maintaining his balance using standard handholds during normal operational acceleration and deceleration dynamics of the vehicle.

Resolution of these problems which inhibit travel by the physically handicapped and the elderly involves: (1) either retrofitting or redesigning both the architectural and mobility features of existing or new transit terminal facilities, (2) the retrofitting or redesign of transit vehicles (e.g. rapid transit cars, buses etc.) to eliminate the types of transit barriers listed in Table 3-1, and (3) the development of procedures for use by vehicle operators which minimize both the spatial discontinuities experienced by the handicapped traveler in ingressing/egressing transit vehicles and the dynamics experienced while the vehicle is in motion.

3.2 VERTICAL MOVEMENT

Probably the single most inhibiting transit problem is that of vertical movement. Almost one third of the respondents to a 1969 sampling(1) of handicapped persons reported that the problem of vertical movement was their basic reason for not using mass transit. The stairway and even the escalator create partial or absolute exclusion to many semi-ambulatory travelers, while representing an absolute exclusion to the non-ambulatory.

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(1) ABT Associates, Inc. "Travel Barrier-Transportation Needs of the Handicapped". Prepared for U.S. Department of Transportation, Office of Economics and Systems Analysis, Cambridge, Mass., August, 1969, 311 pages (PB 187 327).

TABLE 3-1 PHYSICAL/OPERATIONAL TRAVEL BARRIERS TO THE HANDICAPPED

Physical Barriers	Operational Barriers
VEHICLES High step required to enter Difficult to get into or out of seats Seats not available/forced to stand Difficult to reach handholds Cannot see out for landmarks No place to put packages Cannot see or hear location information Non visible signs	VEHICLES Frequency of service Driver assistance/attitude Acceleration/deceleration Information presentation Schedules maintenance Inadequate or inappropriate routes Too many transfers
TERMINALS Long stairs Long walks Poor fare collection facilities Poor posting of information Poor crowd flow design Insufficient seating Poor interface with other modes	TERMINALS Employee assistance/attitude poor Information clarity and dissemination Length of stops too short Crowd flow non-directed Little or no interface with other modes.
TRANSIT STOPS Insufficient shelter Platform incompatible with vehicle Inadequate posting of information	TRANSIT STOPS Poor location: for safety: for convenience Not enough stops Information displayed insufficient or confusing
(2) Ibid, Table VI -IX	

The principal vertical movement devices which might be used to resolve this problem are stair-climbing wheelchairs, stair-mounted lifts for wheelchairs, standard and broad-step escalators, and inclined or vertical shaft elevators. These will be described and discussed in Section 4 in the context of their possible incorporation into typical existing rapid transit stations.

4. VERTICAL MOVEMENT VEHICLES

The types of Vertical Movement Devices identified in this study for possible use by the handicapped and elderly were selected on the assumption that the handicapped rapid transit user would either be confined to a wheelchair or have other limiting/handicapping conditions which would require use of a vertical movement device.

Based on this assumption, the vertical movement device options discussed and described in this section include the following:

1. Vertical Elevator (Paragraph 4.1)
2. Inclined Moving Ramp (Paragraph 4.2)
3. Stair Climbing Wheelchair (Paragraph 4.3)
4. Inclined Stairlift (Paragraph 4.4)
5. Escalator (Paragraph 4.5)
6. Broadstep (Wheelchair) Escalator (Paragraph 4.6)
7. Inclined Elevator (Paragraph 4.7)

The general performance characteristics for each of these vertical movement devices are presented in Table 4-1 and in the related paragraphs of this section.

4.1 VERTICAL ELEVATOR

4.1.1 Performance Characteristics

For transit applications where depths are not excessive, i.e., less than 75 feet, either the hydraulic elevator or the traction electric elevator is generally used. Speeds for the AC electric or hydraulic unit run up to 150 fpm, while the DC electric can be used up to 350 fmp, although speeds of 350 fpm would not generally be required. Capacity is measured in terms of pounds of load and/or number of passengers. For applications considered here,

TABLE 4-1 PERFORMANCE CHARACTERISTICS OF VERTICAL MOVEMENT DEVICES FOR TRANSIT APPLICATIONS

Type of Device	Speed (FPM)	Nominal Capacity	Step Widths	Remarks
Vertical Elevator Electric Hydraulic		200-3500 lb. 10-14 passengers	N/A	High Speed Elevators are Available but are not required for Subway Access
Inclined Moving Ramp	125-180	7000-8500 Persons/Hr	27"-40"	Treadway Speeds Vary with Incline from 125 FPM at 15° Incline to 180 FPM at 0° Incline
Stairclimbing Wheelchair	10-30	One per Trip	N/A	Ascend/Descend Stairs of up to 48° Slope.
Inclined Stairlift	25	Up to 300 lb. One per Trip	40"	
Escalator: Standard & Broadstep (wheelchair)	90-125	3000-8000 Persons/Hr	24"-40"	AC Motor Driven Moving Step Inclined to the Horizontal at Approx. 30° - Widestep see Figure 4-2.
Inclined Elevator	90-125	2000 lb.	N/A	Moves at Same Incline (30°) as at Escalator Each Level to be Accessed would Require a Separate Incline Evaluation.

a 2,000 pound unit capable of handling 10 standees or two wheelchairs and 2 standees would be adequate. To accommodate a 76 x 22 inch mobile stretcher, for possible emergency evacuations, the elevator should have a 2,500 pound car 6 feet 8 inches wide x 4 feet 3 inches deep equipped with a 3 foot 6 inch wide, two speed set of doors.

4.1.2 Discussion

Vertical and inclined elevators are very effective options to implement in existing stations to assist the handicapped and elderly in negotiating level changes, but they require extensive new construction. A primary advantage of vertical elevators is that they require no further development and are readily available. However, they suffer from the potential drawback that the handicapped elevator user may be removed from the normal flow of transit station traffic, when that traffic accesses the stations by means of escalators and/or conventional stairways. This condition becomes more acute as the depth of the station increases. The inclined elevator, on the other hand, satisfies this issue by being capable of operating adjacent to escalators and conventional stairways, thereby, integrating the traffic flow to some extent. Although such units are presently not available commercially, no serious engineering problems are anticipated in their development. Both types of elevators would require extensive transit station reconstruction, involving new shaft ways, some structural enclosures for weather protection and electric hoist ways.

Another advantageous feature of the vertical elevator is the way it controls the flow of movement. By transporting passengers in a vertical direction, it has no major effect on the user's center of gravity and therefore, his or her balance is less likely to be affected. Moreover, because its plane movement is in a single plane, the forces exerted on the rider are minimal and are less likely to affect balance and/or stamina, thus reducing the need for possession of complete coordination abilities. The elevator's mechanism when under a time controlled sequence allows ample time for the handicapped passenger to embark and disembark.

Finally, the elevator, because of its flexibility of operation, presents a wide range of options for adapting to the functional impairments of the handicapped/elderly population.

4.2 INCLINED MOVING RAMP

4.2.1 Performance Characteristics

This device is powered by an AC induction motor which drives a moving belt inclined to the horizontal up to 15°. Treadway speeds vary with the incline from approximately 125 fpm at 15° incline to 180 fpm at 0° incline - the width of the treadway ranges from 27 inches to 39 inches. Travel direction of the unit is reversible.

4.2.2 Discussion

The mechanics of a moving ramp are very much similar to that of an escalator. It replaces the stairs with a conveyor belt and reduces the ascent/descent angle by half, thus increasing the run length for the same level change. Thus the inclined moving ramp due to its slope limitation of 15° would require longer station runs for a given height level, and would have a correspondingly greater impact on existing facilities, if introduced into an existing transit station.

The single continuous moving treads of the inclined ramp also create dynamic problems for the handicapped.

The ambulant and semi-ambulant user must adjust his or her body to the slope movement of the ramp and still be capable of maintaining vertical body attitude. Their feet must be flexible enough to adjust to slope conditions. There must be sufficient bodily resistance to maintain a proper posture ascending and descending. A wheelchair user upon descent must be flexible and coordinated enough to embark the tread, lock the braking mechanics of the chair, resist the vertical forces and be able to perform a reverse procedure upon disembarking. Any slight procedural error or defect in the chair's mechanics can cause a serious safety

hazard for the handicapped user. Ultimately, the disabled user must possess great stamina, coordination and balance to insure not only his or her own personal safety but the safety of the non-handicapped user as well. The usefulness of the inclined ramp to the handicapped and elderly is quite limited because of its inability to accommodate their broad spectrum of bodily dysfunctions.

4.3 STAIRCLIMBING WHEELCHAIR

4.3.1 Performance Characteristics

The stairclimbing wheelchair is, as its name would indicate, a wheelchair so equipped that it can climb up and down stairs. Several versions of this device are possible. It may be completely self-contained, powered either manually by the occupant, or by a battery. Self-contained models would seem to require no modification to transit station stairways to permit their effective operation. Stairclimbing wheelchairs which require an outside power supply during their stairclimbing operations would, on the other hand, require compatible external power source and perhaps other ancillary equipment at each stairway to be used in conjunction with the device. Because the completely self-contained version of the stairclimbing wheelchair does not require modification of existing stairways, it would not seem to be subject to building or other safety codes, which are concerned with the construction and reconstruction of buildings. On the other hand, the stairclimbing wheelchair version, which requires outside power would require station modifications, and such modifications would be subject to code requirements.

This device integrates the two basic mobility functions of vertical and horizontal motion into one device. General requirements include the ability to ascend and descend stairs of up to 48° slope at speeds between 10 and 30 fpm, while retaining the normal functional requirements of a standard wheelchair such as collapsability and portability.

4.3.2 Discussion

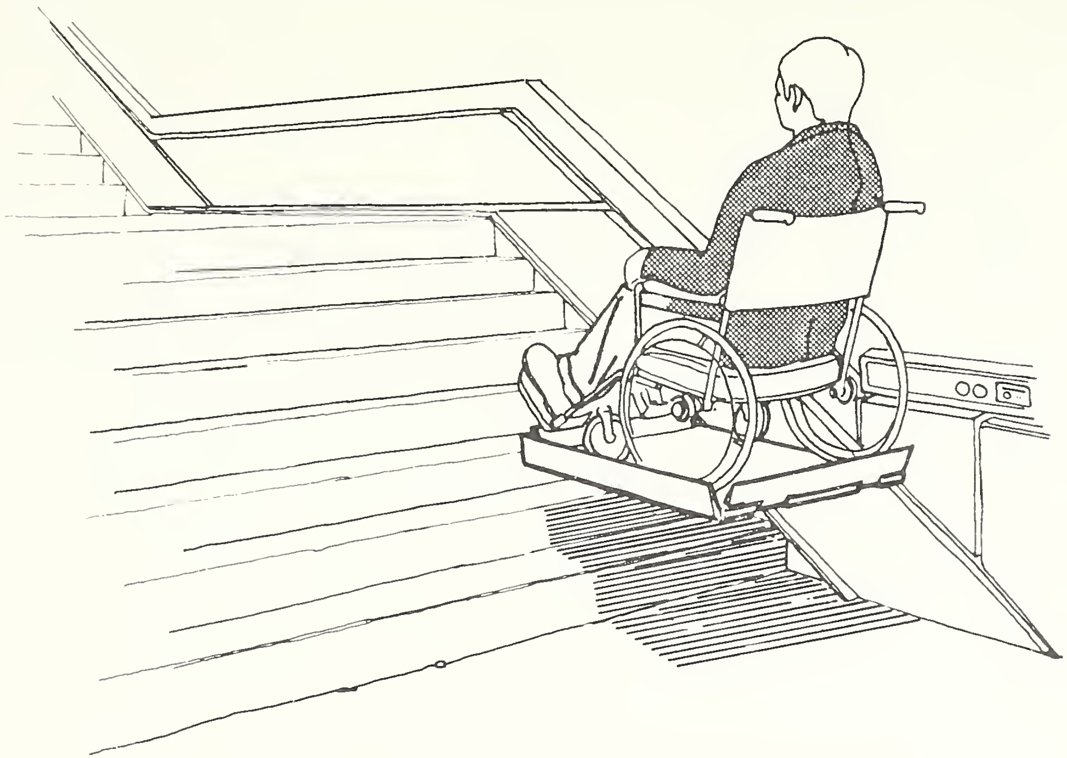
A serious constraint on the use of the stairclimbing wheelchair in a transit station is the general pedestrian volume on existing stairways where these devices would be installed and operated. Further difficulties are posed by the actual width of station stairs, the broken pattern of stairflights, the linearity of stations, the subsurface depth or elevated height of station platforms, and stairway exposure to weather. These conditions impose size restrictions on these devices; require duplicate installations depending on station design; mandate shielding provisions for exposed electrical or mechanical hardware and components and possibly require structural modifications to station stairwells. These provisions are necessary both to properly install these devices and to protect both user and non-user from hazardous interfaces. All such station modifications must adhere to all applicable fire, electrical, safety, elevator, and general building standards, codes and regulations.

The application of the stair climbing wheelchair to the mobility problem of the Handicapped/Elderly (H/E) population is probably the most inflexible solution available among all of the vertical movement devices currently on the market. An analysis of tables 5-1 and 5-2 reveals that the many detailed maneuvers and manipulations would preclude the stair climbing chair application to many dysfunctional situations. Dysfunctions such as nervousness, fear of falling, balance, reaction time, muscular skill, combine to make this a difficult option for use by a wide range of handicapped persons.

4.4 INCLINED STAIRLIFT

4.4.1 Performance Characteristics

The inclined stairlift (see Figure 4-1) is essentially an elevator platform installed within a stairway right-of-way which moves in parallel to and just above the plane of the stairs, rather than in the vertical plane of traditional elevators. The



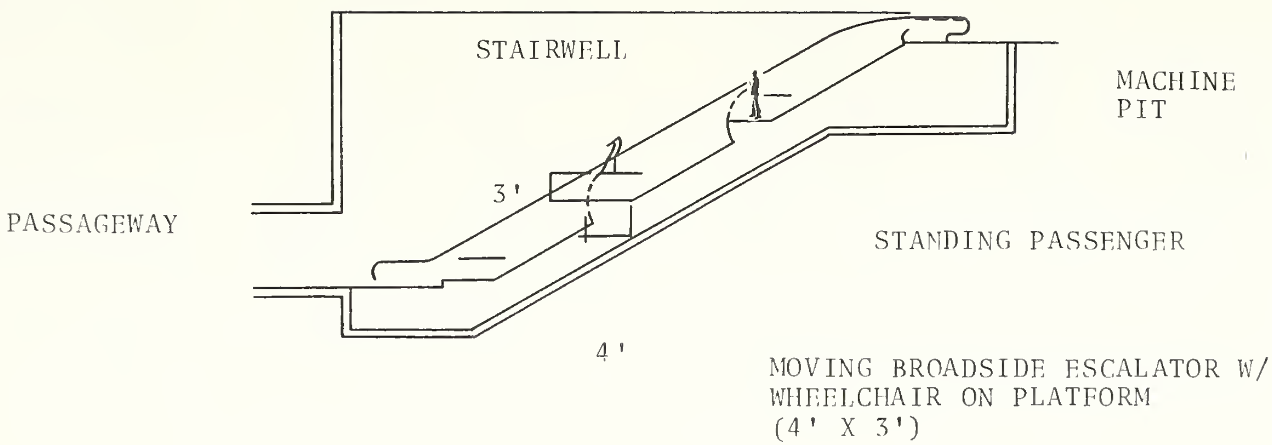
*Reprinted from "Travel Barriers, Transportation Needs of the Handicapped," Abt Associates, 1969

Figure 4-1 Inclined Stairlift Installed In An Existing Transit Station Stairway

entire lift device is affixed to one side to the wall of the stairwell, and may or may not require a track laid on top of the stairs to support the outer end of the lift platform. If such a track were required, installation of this device would permanently occupy a portion of the stairway. If no track were required, that is, if the lift were capable of supporting its expected loads entirely through its connection to the side wall of the stairwell, the lift platform could be designed to fold flush against the sidewall of the stairwell when not in use. In this folded position, the stairway would be usable by ablebodied persons to the same extent as before the device was installed. To use the lift, the platform is lowered down to its horizontal position to receive wheelchair-bound or other passengers. Once a wheelchair rolled onto the platform, ridges in the floor of the platform or other locking devices would prevent the chair from rolling off until the end of the ride. During the time the inclined lift is in use, that portion of the stairway being traversed by the lift would be blocked by gates at both the top and foot of the stairway and would be unavailable for use by pedestrians.

As presently designed, (see Figure 4-2) these units operate at linear speeds up to 25 fpm. Since their application in other than private dwellings has been limited due to stringent building and safety codes, their commercial applicability in terms of reliability/durability has not been demonstrated nor has their ultimate cost been reliably established.

The units themselves are electrically powered (120 or 220 VAC) and driven by a rack and pinion drive or cable device. At least one unit surveyed can be folded against the wall when not in use, extending out approximately 12 inches in the folded position. The platform itself is capable of handling a wheelchair and the controls to the unit are located such that the user can operate the unit. As presently designed, the units can carry up to 300 pounds. In the folded down position the total unit, drive plus platform, requires approximately 40 inches of stairway width. At the present time, this type of unit is capable of carrying a wheelchair in a straight run only. They could not be used on a stairway



ADAPTED FROM "BARRIER FREE RAPID TRANSIT". EDWARD H. NOCKES, POTOMAC VALLEY CHAPTER, AIA, SEPTEMBER, 1969.

Figure 4-2 Broadstep (Wheelchair) Escalator

with corners such as that shown in Figure 6-4. There are available, however, lift devices which carry one seated person and are capable of being installed on stairways which have both turns and platforms. Conceptually, this type unit might be designed to accommodate a platform capable of handling a wheelchair so that it could be employed on stairwells which have platforms and/or 90° turns. Discussions with manufacturers have indicated a need for some substantial engineering development should such a requirement be established.

In normal operation, the user could call the unit and access/egress the platform without help. As a safety feature, the units can only be operated by positive pressure on a button (deadman switch), thus reducing the possibility of injury to user or non-user in the event of an obstruction in the stairwell. If units were not available which could negotiate platform turns, transfers would be required for each level or turn. At the present time, these units are not covered by any nationally accepted elevator code. (See Section 7.)

4.4.2 Discussion

Although this device is used in private dwellings and some federal buildings, the use of the device for transit access had never been seriously considered up to this time.

Any future transit system application of the stairlift will be dependent on the ability of the unit design to integrate the unit's mechanical system into transit station stairways used by the general public. This factor must be considered in conjunction with design features mandatory from the handicapped users point-of-view (see Tables 1-5 & 1-6).

User safeguards will have to be devised that will accommodate the wide range of handicapped dysfunctions. Provision must be made not only for physical weaknesses such as balance and stamina deficiencies but also for the manipulation and coordination skills of the wheelchair user. Guards, front and back stops, grab bars, stanchions and caging must be designed so to accommodate the largest

majority of disabled persons. These support needs are especially crucial to the transit system integration of persons with motion sensitivity deficiencies.

If proper designs can be evolved, the stair lift could have widespread applicability in terms of providing mobility to a large percentage of the handicapped population to be addressed.

However, at the present time the installation of inclined stairflifts presents a safety hazard in most existing stations. The incorporation of this device would significantly impede normal traffic flow on the stairways and would encroach on the egress requirements of public building codes.

4.5 ESCALATOR

4.5.1 Performance Characteristics

The escalator features an AC motor-driven, moving step inclined to the horizontal at approximately 30°. Speeds vary from 90 to 120 fpm with step widths randing from 24 inches to 40 inches. The escalator is reversible.

4.5.2 Discussion

Functional deficiencies inherent in a handicapped person's condition and/or mobility aid, coupled with normal skills required for successful transit, would preclude the escalator's use by a large segment of the handicapped/elderly population. (see Tables 1-5 and 1-6).

The physical design of the escalator can not accommodate the wheelchair or walker. The kinetic dynamics of the escalator are such that users of other special aids which require a firm stationary platform for mounting and dismounting would also be severly restricted or completely limited. The continuous movement of the escalator is not manageable by many persons whose manipulative and coordination control and stamina are deficient.

4.6 BROADSTEP (WHEELCHAIR) ESCALATOR

4.6.1 Performance Characteristics

The broadstep escalator (wheelchair escalator) is presently in the conceptual stage of development. It would be designed with a tread length long enough to accommodate a wheelchair, approximately 4 feet, resulting in a riser in excess of 2 feet. A stop/start capability would have to be included to permit the handicapped to access the unit. For safety, the unit would also require hand rails along the side of the escalator which could be grasped by the wheelchair occupant, and a retractable safety rail to protect the user from falling down the two (2) foot riser.

4.6.2 Discussion

Intrinsically, the broadstep escalator cannot operate continously as does a standard escalator but must cyclically start and stop. The need for this feature is obvious in order to accommodate the wheelchair users in the handicapped/elderly population. However, other individuals who have balance difficulties due to leg braces, artificial limbs or other special devices would probably find the ascent/descent trip difficult due to the repeated stop-start-stop action during a single run, needed to egress other travelers. The broad-step escalator, while it might be compatible with a station already having an escalator, would probably require a special shaft excavation to accommodate the broadstep design. Depending on station designs and service volumes, each platform must have at least two units, one up, and one down. Provisions for weather and security must be provided. Since these units require the start/stop feature for load/unload of persons with certain hanicapping dysfunctions, this feature will limit usefulness for non-handicapped use, and could present a safety problem to individuals on the unit and subject to the start/stop dynamics. (See also the discussion of the stair-climbing wheelchair in paragraph 4.3.2, above).

4.7 INCLINED ELEVATOR

Conceptually similar to the standard vertical elevator[1], the inclined elevator moves at the same incline as the escalator (30°). Inclined elevators are in use in Europe; applications in the U.S. are extremely rare. No known application exists in transportation terminals or stations.

Such a unit would be installed in a fully separated shaftway so as to achieve inherent safety advantages of enclosure. An advantage of the inclined elevator over a vertical unit for transit access lies in the possibility of arranging a common street-level exit and entrance with stairs or escalators, thereby better integrating the overall flow of traffic. Although there may be engineering limitations associated with a specific station, where an inclined unit could serve as the most cost-effective installation, as a general rule, the inclined elevator is somewhat more expensive than the verticle elevator (Reference: Section 6.5). The unit size would be identical to that of the 2,000 pound vertical elevator cab and speeds would be comparable to an escalator. Doors, however, are required at both ends of the cab for access/egress. Each level to be accessed would require a separate inclined elevator.

[1] See also the discussion of the Vertical Elevator in paragraph 4.3.2, above.

5. RELATING ACCESS OPTIONS TO HUMAN DYSFUNCTIONS

In this section several correlations are offered between the dysfunctional characteristics of handicapped/elderly population and the operational aspects of the vertical movement devices discussed in Section 4. Tables 5-1 thru 5-3 organize this assessment of the functional utility of different devices:

1. Table 5-1 provides a matrix relating each of six types of vertical movement devices to the sequences of activities required for its operation and use.
2. Table 5-2 identifies the inherent problems associated with each major type of vertical movement device as it impacts the physical dysfunctions and mobility restraints of the overall handicapped population.
3. Table 5-3 relates the applicability of various vertical movement devices to the major classes of handicaps. This table indicates that inclined and vertical elevators represent the devices most applicable to the broadest spectrum of the physically handicapped, with the inclined stairlift ranking close behind.

Based on these admittedly simplistic analyses, it is evident that elevator systems require fewer operating functions and less physical and mobility dexterity, thus accommodating more classes of handicapped and elderly people.

TABLE 5-1 VERTICAL MOVEMENT DEVICE - FUNCTIONAL ACTIVITY MATRIX

Required Functional Activity / Vertical Movement Device	Elevators	Inclined Moving Ramp	Stairclimbing Wheelchair	Inclined Stairway Lift	Escalator	Broadstep Escalator
Call (by activation)	●	NA	NA	●	NA	NA
Enter alight standing	●	●	●	●	●	●
Alight Moving	NA	●	NA	NA	●	NA
Activate device	●	NA	●	●	NA	●
Hold device (control)	NA	NA	●	●	NA	●
Stand Posture	●	●	NA	●	●	●
Sit Balance	●	●	●	●	NA	●
Grasp	NA	●	●	●	●	●
Balance	●	●	●	●	●	●
Deactivate	NA	NA	●	●	NA	●
Disembark Standing (Vehicle Standing)	●	NA	●	●	NA	●
Disembark Moving	NA	●	NA	NA	●	NA
Regain Composure	NA	●	●	NA	●	NA

Key: ● - Required Function
NA - Not required or not applicable

TABLE 5-2 VERTICAL MOVEMENT DEVICES VS MOBILITY/PHYSICAL DYSFUNCTIONS

Type of Dysfunction / Type of Vertical Movement Device	Mobility Restraints	Physical Restraints
Elevators	Maintaining posture	Lengthened reaction time, wheelchair que (buffer zone)
Inclined Moving Sidewalk (Ramp)	Clutching, gripping, walking, moving, manipulating, maintaining posture, unsteady, slow thinking, balancing stamina, coordination, sitting balance.	Decreased visual skill, sensitive to motion, reduction of muscular skill, reduced ability to maintain balance, lengthened reaction time, reduction of stamina, reduction in bone flexibility, fear of falling, nervousness, wheelchair buffer zone, crutch buffer zone, cane buffer zone, brace buffer zone, blind buffer zone.
Stairclimbing Wheelchair	Standing from sitting, sitting from standing, ability to sit, carrying, reaching up, reaching down, clutching, gripping, manipulating, sitting balance, maintaining posture, nsteady, balancing, coordination.	Decreased visual skill, sensitive to motion, reduced muscular skill, reduced ability to maintain balance, lengthened reaction time, reduced coordination, reduced oone flexibility, weakness of bones, fear of falling, nervousness, wheelchair buffer zone, crutch buffer zone, cane buffer zone.

TABLE 5-2 VERTICAL MOVEMENT DEVICES VS MOBILITY/PHYSICAL DYSFUNCTIONS - CONTINUED

Type of Dysfunction / Type of Vertical Movement Device	Mobility Restraints	Physical Restraints
Inclined Stairway Lift	Gripping, moving, sitting balance, maintaining posture, slow thinking, balancing, co-ordination.	Decreased visual skill, sensitivity to motion, reduction of muscular skill, reduced ability to maintain balance, lengthened reaction time, reduced coordination, fear of falling, nervousness, wheelchair buffer zone.
Escalators	Clutching, gripping, walking, moving, manipulating, maintaining posture, unsteady, slow thinking, balancing, coordination, sitting balance.	Decreased visual skill, sensitive to motion, reduction of muscular skill, reduced ability to maintain balance, lengthened reaction time, reduction of coordination, reduction in bone flexibility, fear of falling, wheelchair buffer zone, crutch buffer zone, cane buffer zone, braces, visions.
Broadstep Escalator	Reaching up, and reaching down, clutching, gripping, walking, maintaining posture, unsteady, balancing, slow thinking, climbing coordination.	Poor visual skill, reduced muscular skill, reduced ability to maintain balance, reduction of coordination, reduction in bone flexibility, disorientation, fear of falling, nervousness, wheelchair buffer zone.

TABLE 5-2 VERTICAL MOVEMENT DEVICES VS MOBILITY/PHYSICAL DYSFUNCTIONS - CONTINUED

Type of Dysfunction / Type of Vertical Movement Device	Mobility Restraints	Physical Restraints
Fixed Stairway	Reaching up and reaching down, clutching, gripping, walking, moving, manipulating, maintaining posture, unsteady balancing, climbing, stamina, coordination.	Decreased visual skill, reduced muscular skill, reduced bone flexibility, fear of falling, nervousness, crutch buffer zone.
Inclined Elevators	Maintaining posture, balancing.	Lengthened reaction time, sensitive to motion, wheelchair buffer zone.
Inclined Stationary Sidewalk (Ramp)	Gripping, walking, moving, maintaining posture, unsteady, balancing, climbing, stamina, coordination, sitting balance. Fear of falling, nervousness, wheelchair buffer zone, crutch buffer zone, cane buffer zone, brace buffer zone.	Decreased visual skill, reduced muscular skill, lengthened reaction time, reduced ability to balance, reduced pacing length, reduction in coordination, reduction bone flexibility.

TABLE 5-3 APPLICABILITY OF VERTICAL MOVEMENT DEVICES TO MAJOR CLASSES OF HANDICAPS

Major Handicap Class / Type of Vertical Movement Device	Vertical Elevator	Inclined Elevator	Inclined Moving Ramp	Stairclimbing Wheelchair	Inclined Stairlift	Standard Escalator	Broadstep Escalator	Ramp	Long Stairs	Short Stairs
Visual Impairment	A	A	ND	NA	A	ND	ND	A	A	A
Hearing Impairment	A	A	A	NA	ND	A	ND	A	A	A
Wheelchair	A	A	ND	A	A	NA	A	A	NA	NA
Walker	A	A	NA	NA	A	NA	ND	NA	NA	NA
Other Special Aids	A	A	NA	NA	A	NA	ND	A	NA	A
Other Mobility Limitations	A	A	NA**	NA	A	NA**	ND	A*	NA	A
Temporary Acute Conditions	A	A	NA	NA	A	NA	ND	A	NA	A

Notes:

*Except for cardiac and pulmonary problems for long ramps.

**Applicable to cardiac and pulmonary problems.

Key:
A - Applicable
NA - Not Applicable
ND - Not Desirable

6. RAPID RAIL TRANSIT STATION ASSESSMENT

6.1 INTRODUCTION

The rapid rail transit system reviewed in this study is typical of older transit systems in the United States. The system reviewed includes many stations in need of renewal and others which have been or are in the process of being modernized. Although modernization has eliminated many deficiencies (e.g., inadequate lighting), the problem of accessibility to the stations by the handicapped and the elderly still has not been adequately addressed.

6.2 STATION CHARACTERISTICS

The stations surveyed present different designs for traveler access. As a result there can be no universal solution to providing improved vertical movement. Entries, ticketing areas and platforms are combined in different ways at varying depths, and at different longitudinal locations. Stairways range in width, depth, angle from the vertical, rise height, tread depth, and illumination levels. Moreover, stairways often are disadvantageously exposed to the elements. Stairways were found to be fairly narrow, with the average width being eight feet. Metallic treads and nosings, frequently exposed to the weather, are slippery, creating an added mobility problem. Access/egress locations, sidewalk and street boundaries, platform configurations, and other such limiting factors make stairway modification or entrance widening difficult, if not impossible.

In many instances the same stairways are used for both entering and exiting the station. The installation or use of powered devices (inclined lifts must be three feet wide to accommodate a wheelchair) in these stairways could severely interfere with the access/egress requirements at the stations for the general public.

Figures 6-1 through 6-4 below illustrate typical station entrances and exits which pose different access problems for the elderly and disabled.

Figure 6-1 Typical Stairway in Older Transit Station (Divided-Multi-Level)

Figure 6-2 Typical Stairway in Older Transit Station (Undivided)

Figure 6-3 Typical Stairway in Older Transit Station
(Divided-Escalator Adjacent)

Figure 6-4 Typical Stairway in Older Transit Station (Undivided w/Corner)

Despite these deficiencies, approximately 25% of the stations in the system could be made more accessible through minor facility modifications such as the addition of curb ramps and the widening of ticketing access gates.

6.3 STATION TRAVEL BARRIERS

The travel barriers in these older established transit system stations are a consequence of the station's physical setting, whether elevated, at grade or below surface. The mixture of these station types with different vertical elevations, sometimes two or three stories high but varying in their degree of exposure to the weather, compounds the problem of achieving a simple and complete classification of stations and their barriers. In general, each station design surveyed presented unique access/egress requirements both in terms of entry location and identification, and method of level change. Many stations surveyed egressed directly to main pedestrian places, some provided convenient pavillions, and some very linear designs were accessible only by means of long skybridges and rambling, staired, scaffolded structures. Some facilities required movement through major buildings, not transportation related; these buildings in turn posed their own travel barriers.

The current primary means of access to the stations studied was by conventional and powered stairways. Although electrical stairways are unequalled for vertical mass movement of the general public, they do require coordination, balance, and self-confidence which exceed the capabilities of many elderly and handicapped persons.

The wide variety of station data collected and barriers identified would make difficult a straightforward cost evaluation. Stations varied in their platform configuration, access/egress characteristics and grade levels.

Typical cross-sections of several of these station types are illustrated in Figures 6-5 through 6-7. Parametric cost studies were performed on three types of stations: (1) a below grade, side platform station; (2) an above grade, side platform station, and

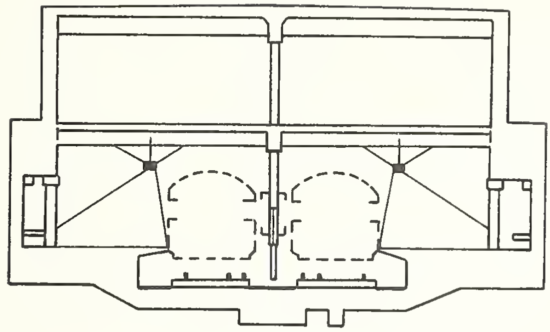


Figure 6-5 Cross Section of a Side Platform-Below Grade Transit Station (Type 1)

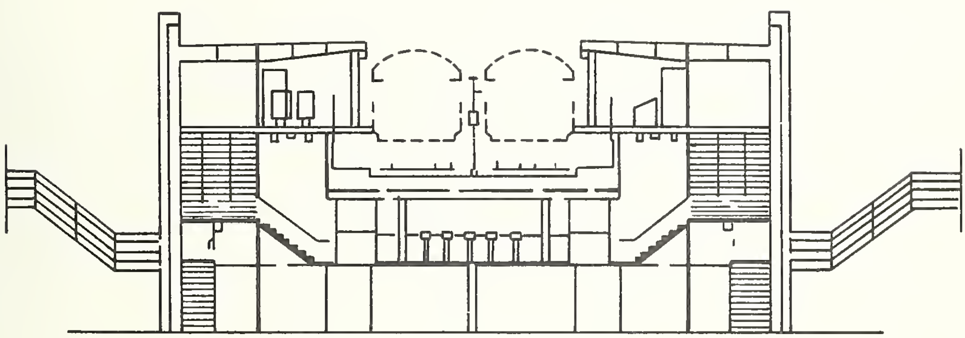


Figure 6-6 Cross Section of a Side Platform-Above Grade Transit Station (Type 2)

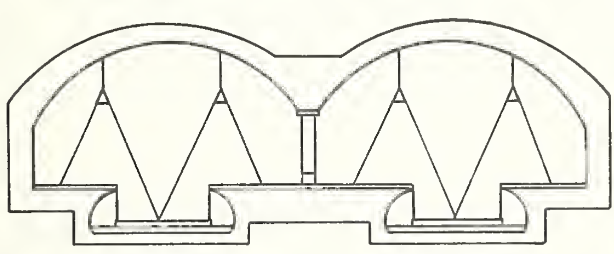


Figure 6-7 Cross Section of a Side Platform-Below Grade Transit Station (Type 3)

(3) a below grade, two level, combination center/side station having some of its existing ingress/egress points housed in weather protective enclosures. These three types of stations were considered typical of above and below grade stations and are discussed further in subsequent paragraphs and in Appendix A where they are referred to as transit Stations types 1, 2 and 3 respectively.

At-grade stations surveyed varied from those which could be made accessible with a minimum effort, to those which would require a detailed architectural study.

6.4 PARAMETRIC CAPITAL COST ANALYSIS

6.4.1 Assumptions

A parametric capital cost study was performed for the three station types described below in paragraphs 6.4.2.1 through 6.4.2.3. Only capital costs were considered. Operating costs and land "right of way" costs were not included. Usage by the handicapped and elderly was not estimated and costs were not allocated in terms of traffic volume.

Conveyor-like devices, (e.g., the inclined moving ramp and escalator) were assumed to require a separate up and separate down traveling unit for each directional lane of transit rail service. (See Table Note #1, page 6-14).

The cost study assumed that the transit operating authority would own the wheelchairs and that each transit station stairwell would require two stairclimbing wheelchairs, one at the bottom, one at the top. These units would share a stairwell with walking traffic.

For elevator-type devices (the inclined elevator and vertical elevator and the inclined stairlift), it was assumed that one unit would handle both entrance and exit requirements. For the inclined stairlift, it was assumed that the unit would be separated from walking traffic by a barrier. Inclined elevators require access doors both front and rear. In addition, since they can only provide one flight or level change for each installed unit, it must be assumed that a separate inclined elevator system is required for each level

to be accessed. Unlike vertical elevators, inclined elevators cannot access multiple levels from a common shaftway. For further assumptions regarding the cost analysis, see Tables 6-1 through 6-3 and Appendix A.

6.4.2 Cost Assessment

The relative costs for the installation of various kinds of vertical movement devices are shown in Tables 6-1 through 6-3 for the three types of transit station configuration.

6.4.2.1 Type 1 Transit Station - The Type 1 station is representative of an on-line, below grade, side platformed configuration. It is typical of many structures in older systems in that it is of rather shallow depth (16 feet street level to platform) with a single portal opening for egress and a single portal opening for ingress at each platform. Stairs are straight with an intermediate landing. Street level entrances and exits are on opposing sides of the street with no provisions for platform change within the station. Table 6-1 compares the relative cost of implementing vertical movement devices in Type 1 Stations.

6.4.2.2 Type 2 Transit Station - The Type 2 Station is an on-line, above grade, side platform configuration station, typical of many older systems, with a platform height of 22 feet, exposed to the weather and supported by an exposed steel framework. The side facing platforms each require separate ingress and egress. They are entered from opposite sides of the street. Vertical movement device installation costs for the Type 2 station are presented in Table 6-2.

6.4.2.3 Type 3 Transit Station - The Type 3 station is a terminal serving as an exchange between the same and other modes of travel. It is a double-decked, below grade station consisting of mezzanine and platform levels with combined side and center platforms. Platforms are accessed from the mezzanine level from which egress/access is directly to the street. Unlike Types 1 and 2, in the Type 3 station street ingress/egress points are housed in

TABLE 6-1 TYPE 1 TRANSIT STATION VERTICAL MOVEMENT DEVICE INSTALLATION COSTS

Vertical Movement Device Type	Hydraulic Elevator (Low Rise System)	Inclined Moving Ramp	Stair-Climbing Wheelchair	Inclined Stairlift	Escalator	Broadstep Escalator	Inclined Elevator	See Appendix A
Cost Element								
Surface Entrance	20,160	-	-	-	-	-	20,160	Par. A-2
Contractor Mobilization	5,000	5,000	1,500	1,500	2,500	1,500	5,000	Par. A-3
Unit Installation	48,000	90,000	2,800	15,270	89,000	223,250	111,500	Par. A.4
Excavation/Shaft Construction	30,000	40,000	-	-	-	-	17,000	Par. A.5
Demolition/Structural Modification	1,900	2,400	-	-	1,440	1,900	1,440	Par. A.6
Equipment Room	13,500	-	-	-	-	-	5,600	Par. A.7
Enclosures	18,000	17,500	3,000	3,000	3,000	3,000	13,700	Par. A.8
Power Installation	1,200	-	-	-	-	-	-	Par. A.9
Surveillance Equipment	5,400	-	-	-	-	-	-	Par.A.10
Signs	1,200	1,200	1,200	1 200	1,200	1,200	1,200	Par.A.11
Snow Melting Equipment	560	560	560	560	560	560	560	Par.A-12
Fare Collection Equipment	-	-	-	-	-	-	-	Applicable But Not Costed See Par.A.13
Subtotal*	145,820 x2	156,660 x4	9,060 x4	21,530 x2	97,770 x4	231,410 x4	176,180 x2	
Type I Total	291,640	626,640	36,240	43,060	390,800	925,640	352,360	

*See Note #1.

TABLE 6-2 TYPE 2 TRANSIT STATION VERTICAL MOVEMENT DEVICE INSTALLATION COSTS

Vertical Movement Device Type	Vertical Elevator**	Inclined Moving Ramp	Stair-Climbing Wheelchair	Inclined Stairlift	Escalator	Broadstep Escalator	Inclined Elevator	See Appendix A
Cost Element								
Surface Entrance	20,160	-	-	-	-	-	20,160	Par. A.2
Contractor Mobilization	5,000	5,000	1,500	1,500	2,500	1,500	5,000	Par. A.3
Unit Installation	48,000	90,000	2,800	15,270	89,000	223,250	111,500	Par. A.4
Excavation/Shaft Construction	-	-	-	-	-	-	-	Par. A.5
Demolition/Structural Modification	1,900	2,400	-	-	1,440	1,900	1,440	Par. A.6
Equipment Room	5,600	-	-	-	-	-	5,600	Par. A.7
Enclosure	19,500	20,150	5,000	5,000	10,500	10,500	10,500	Par. A.8
Power Installation	1,200	-	-	-	-	-	-	Par. A.9
Surveillance Equipment	5,400	-	-	-	-	-	-	Par. A.10
Signs	1,200	1,200	1,200	1,200	1,200	1,200	1,200	Par. A.11
Snow Melting Equipment	560	560	560	560	560	560	560	Par. A.12
Fare Collection Equipment	-	-	-	-	-	-	-	Applicable But Not Costed See Par. A.13.
Subtotal*	108,520 x2	119,310 x4	11,060 x4	23,530 x4	105,200 x4	238,910 x4	155,960 x2	
Type II Total	217,040	477,240	44,240	94,120	420,800	955,640	311,920	
*See Note #1.								

TABLE 6-3 TYPE 3 TRANSIT STATION VERTICAL MOVEMENT DEVICE INSTALLATION COSTS (STREET/MEZZANINE)

Vertical Movement Device Type	Vertical Elevator	Inclined Moving Ramp	Stair-Climbing Wheelchair	Inclined Stairlift	Escalator	Broadside Escalator	Inclined Elevator	See Appendix A
Cost Element								
Surface Entrance	20,160	-	-	-	-	-	20,160	Par. A.2
Contractor Mobilization	5,000	5,000	1,500	1,500	2,500	2,500	5,000	Par. A.3
Unit Installation	48,000	90,000	2,800	15,270	89,000	223,250	111,500	Par. A.4
Excavation/Shaft Construction	60,000	40,000	-	-	-	-	32,000	Par. A.5
Demolition/Structural Modification	1,400	2,400	-	-	1,440	1,900	3,800	Par. A.6
Equipment Room	5,600	-	-	-	-	-	5 600	Par. A.7
Enclosure	24,000	17,500	5,000	5,000	5,000	3,000	27,500	Par. A.8
Power Installation	1,200	-	-	-	-	-	-	Par. A.9
Surveillance Equipment	5,400	-	-	-	-	-	-	Par. A.10
Signs	1,200	1,200	1,200	1,200	1,200	1,200	1,200	Par. A.11
Snow Melting Equipment	560	560	560	560	560	560	560	Par. A.12
Fare Collection Equipment	-	-	-	-	-	-	-	Applicable But Not Costed See Par. A.13
Subtotal*	172,520 x1	156,600 x2	11,060 x2	23,530 x1	99,700 x2	232,410 x2	207,320 x1	
Type III Total (Street/ Mezzanine Costs)	172,520	313,320	22,120	23,530	199,400	464,820	207,320	
*See Note #1.								

TABLE 6-4 TYPE 3 TRANSIT STATION VERTICAL MOVEMENT DEVICE INSTALLATION COSTS (MEZZANINE/PLATFORM)

Vertical Movement Device Type	Vertical Elevator	Inclined Moving Ramp	Stair-Climbing Wheelchair	Inclined Stairlift	Escalator	Broadstep Escalator	Inclined Elevator	See Appendix A
Cost Element								
Surface Entrance	-	-	-	-	-	-	-	-
Contractor Mobilization	-	-	-	-	-	-	-	-
Unit Installation	-	90,000	2,800	15,270	89,000	223,250	111,500	Par. A.4
Excavation/Shaft Construction	-	40,000	-	-	-	-	17,500	Par. A.5
Demolition/Structural Modification	-	2,400	-	-	1,440	1 900	1,900	Par. A.6
Equipment Room	-	-	-	-	-	-	-	-
Enclosure	-	18,000	3,000	3,000	3,000	3,000	13,750	Par. A.8
Power Installation	-	-	-	-	-	-	-	-
Surveillance Equipment	-	-	-	-	-	-	-	-
Signs	-	-	-	-	-	-	-	-
Snow Melting Equipment	-	-	-	-	-		-	-
Fare Collection Equipment	-	-	-	-	-	-	-	-
Subtotal*	-0-	150,400 x2	5,800 x2	18,270 x2	93,440 x2	228,150 x2	144,650 x1	
Type III Total (Mezzanine/Platform)	-0-	300,800	11,600	36,540	186,880	456,300	144,650	
Type III Totals (Street/Mezzanine)	172,520	156,600	22,120	23,535	199,400	464,820	207,320	
Type III Grand Total	172,520	457,400	33,720	60,075	386,280	921,180	351,970	
*See Note #1.								

NOTE #1 FOR TABLES 6-1 THRU 6-4

Sub-total multipliers are based on necessary number of unit installations to achieve a minimum per entry multi-directional traffic flow.

Example: Escalator = 4 X (N)

1 Station = 2 Entries

1 Entry = 2 one-way traffic flows

1 Escalator = 1 one way traffic flow

2 Entries = 2 X 2 one way traffic flows

= 4 Escalators = 4 one way traffic flows

weather protective enclosures. The mezzanine level is 15 feet below the mezzanine level. Tables 6-3 and 6-4 give the relative costs for installing vertical movement devices in a Type 3 Station.

The cost analyses of Tables 6-3 through 6-4 show that, for all of the station types assumed, non-standard device applications (i.e., stairlift, stairclimbing wheelchair) offer the lowest installation costs. Standard devices (i.e., elevators) had significantly higher installation costs, followed by the conveyor type device. The device ranking according to cost is as follows:

1. Stairclimbing wheelchair,
2. Inclined stairlift,
3. Vertical elevator,
4. Inclined elevator,
5. Escalator,
6. Inclined moving ramp,
7. Broadstep escalator.

Stations of greater height or depth, with more flights and turns in stairwells, or more extensive weather exposure, will cost more to renovate than those with simpler configurations.

These comparative installation costs are only valid within the framework of the assumptions as to vertical movement devices and transit station types used in this analysis.

7. LEGAL/LIABILITY ASSESSMENT OF TWO NON-STANDARD DEVICES

7.1 INTRODUCTION

Two non-standard devices, an inclined stairlift and a stair-climbing wheelchair (both previously described in Section 4 above) appear to be attractive as relatively low-cost means to make existing fixed-rail transit stations accessible to handicapped persons, especially those in wheelchairs. This section identifies the legal restraints which may restrict or inhibit the use of such devices to assist wheelchair-bound persons. Such legal barriers include building and other construction codes, and the risk of legal liability arising out of accidents involving the devices.

This review is limited to the legal factors affecting one particular fixed-rail transit operator--the Massachusetts Bay Transportation Authority (MBTA), which operates the fixed-rail system in the Greater Boston area. To the extent that Massachusetts law is similar to national codes adopted in other jurisdictions, however, the results with respect to the MBTA may be generalized to other areas.

This analysis of Massachusetts' law was performed prior to effective date of a new single, unified building code,[1] incorporating specialized construction codes governing electrical installation, plumbing, elevators, etc.[2] This discussion will consider both the law and regulations now in effect and, where possible, the relevant changes made by the new code.

The two devices considered in this section were selected because they require minimal station reconstruction for their installation, and so represent relatively low-cost means to provide access to elevated or underground mass transit stations. The other

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[1] Mass. Gen. Laws c.23B, Sec. 16, and accompanying note (see Acts of 1972, c. 802, Sec. 67). Effective date was January 1, 1975.

[2] Mass. Gen. Laws c.23B, Sec. 19.

vertical movement devices described in this report were not subjected to this type of legal liability assessment, since building, construction and safety codes and regulations exist which govern their use.

7.2 APPLICABILITY OF CONSTRUCTION CODES TO MBTA

7.2.1 MBTA's Statutory Exemption from State Construction Codes

The Massachusetts Bay Transportation Authority (MBTA) enabling act specifically exempts the Authority from most regulations issued by other state agencies. The Authority is authorized "To provide mass transportation service...without being subject to the jurisdiction and control of the Department of Public Utilities in any manner except as to safety of equipment and operations and, with respect only to operations of the authority with equipment owned and operated by the authority, without, except as otherwise provided...being subject to the jurisdiction and control of any city or town or other licensing authority.... The directors of the authority shall determine the character and extent of the services and facilities to be furnished, and in these respects their authority shall be exclusive and shall not be subject to the approval, control or direction of any state, municipal or other department, board or commission."[(3)] As this text indicates, the MBTA is not subject to the control of any other state regulatory body with regard to the "facilities" it provides.[(4)] The policy behind the above-quoted provision is indicated in a Massachusetts Attorney General opinion dealing with the applicability of state and local plumbing regulations to MBTA facilities.[(5)] The opinion cites the title of the statute containing the above-quoted section, "An Act

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(3) Mass. Gen. Laws Ann. c.161A, Sec. 3(i).

(4) "Mass transportation facilities" are defined to include "all real property (including land, improvements, terminals, stations, ...)...used in connection with the mass movement of persons." Mass. Gen. Laws Ann. c.161A, Sec. 1.

(5) 1966 Op. Atty. Gen. 66.

excluding operations of the Massachusetts Bay Transportation Authority with equipment owned and operated by said Authority from the jurisdiction and control of city, town, and certain other licensing authorities" and concludes that there exists "a clear legislative intent to exclude the MBTA from local jurisdiction and control."[6]

7.2.2 Role of Construction Codes in MBTA Station Construction

In view of this broad exemption from most state agency regulation (the exception stated in the above-quoted excerpt, the Department of Public Utilities control over "safety of equipment and operations," will be discussed later), it might well be concluded that the MBTA is free to incorporate either inclined stairway passenger lifts, or to provide support facilities needed to power stairclimbing wheelchairs, without regard to requirements or restrictions contained in otherwise applicable elevator, electrical, or other construction codes. While technically this conclusion appears correct, in fact the MBTA pays considerable attention to the content of such codes.[7] This is done to insure the MBTA facilities are constructed in accordance with standard and accepted practices, and/or to protect the Authority from sub-standard workmanship. Further, adherence to applicable codes provides some assurance that the facilities are reasonably safe for public use. In particular, the architect in charge of station design for the MBTA stated in an interview that the Authority would attempt to follow state regulations generally applicable to the design, construction and operation of elevators and escalators.[8] In light of this practice by the MBTA, it is appropriate to review the regulations governing installation of inclined stairway passenger lifts in Massachusetts.

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(6) _Id._ at 68.

(7) Telephone interview with John Williams, architect in charge of station design for the MBTA (May 28, 1974).

(8) _Id._ Mr. Williams also stated that is was the MBTA's practice to follow the strictest electrical code which would otherwise be applicable to its activities.

7.2.3 An Overview of the Statutory Scheme for Regulation of Inclined Stairway Passenger Lifts in Massachusetts

Inclined stairway passenger lifts come under the jurisdiction of the "Board" of Elevator Regulations," established within the Massachusetts Department of Public Safety, which has general authority to regulate elevator installation, maintenance and operations.[9]

> "The Board of Elevator Regulations shall frame amendments to the regulations relating to the construction, installation, alteration and operation of all elevators, and relative to the location, design and construction of shafts or enclosures for elevators, safety devices, gates or other safeguards, protection against the elevator or hoisting machinery, and means to prevent the spread of fire, and also amendments to the regulations designed to make uniform the work of the inspectors of the Division of Inspection of the Department and of inspectors of buildings throughout the Commonwealth."[10]

No elevator[11] may be installed or altered unless a copy of plans describing the proposed installation or alteration are filed with a local elevator inspector and approved by him.[12]

Regulations issued by the Board of Elevator Regulations contain special provisions governing installation of inclined stairway passenger lifts in private residences and multiple dwellings.

> "A private residence inclined passenger lift is a power lift installed in a private residence or a multiple dwelling as a means of access to a private residence in such a building, but only if the inclined lift is so installed and is not accessible to the general public or to any of

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(9) Mass. Gen. Laws Ann. c.22, Sec. 11.

(10) Mass. Gen. Laws Ann. c.143, Sec. 68.

(11) The term "elevator" includes moving stairways, Mass. Gen. Laws Ann. c.143, Sec. 71E.

(12) Mass Gen. Laws Ann. c.143, Sec. 62.

> the occupants of the building other than the person for whom it was installed.[13]

Therefore, the regulations contain no provisions dealing with installation of inclined lifts in other settings, installations of inclined stairway lifts in other than private residences of multiple dwellings would presumably be subject to the regulations' general requirements for elevator installation, including the requirement that the hoistway in which the elevator operates be enclosed throughout its height.[14]

The policy behind the provision for the installation of private inclined stairway passenger lifts is indicated in the model elevator code promulgated by the American Society of Mechanical Engineers.[15] (The regulations concerning such lifts adopted by the Massachusetts Board of Elevator Regulations appear to be based almost verbatim on this model code.) In introducing the section on inclined stairway lifts, the model code states:

> "This part of the Code has been developed in response to demands for a separate section of rules to cover the installation in a private residence of a small electric power passenger elevator or inclined lift which serves only the members of a single family...
>
> "It is frequently necessary to install such elevators in open stairwells, as the construction of the building does not provide space to permit installing a standard type of enclosed hoistway inside the building.

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(13) Massachusetts Department of Public Safety (Board of Elevator Regulations), "Elevator, Dumbwaiter, Escalator, and Moving Walk Regulations--ELV-2," (Dec. 10, 1971) (hereafter referred to as "ELV-2 Elevator Regulations"). The regulations issued by the Board of Elevator Regulations have been incorporated in their entirety in the new State Building Code. Massachusetts State Building Code Commission, Massachusetts State Building Code," Art. 16 (filed July 1, 1974).

(14) "ELV-2 Elevator Regulations," Sec. 11.01.

(15) American Society of Mechanical Engineers, "American Standard Safety Code for Elevators," (A 17.1-1965), Part 5 (1965 edition).

"Due to their limited size, speed, load, and travel, and the fact that their use is limited to the members of a single family and is under the control of the head of the family, adequate safety of operation can be secured without requiring that such equipment meet the standards set up in other parts of this code for equipment installed in buildings of other types which are used by the general public and are thus subjected to much more severe and frequent use."[16]

(emphasis added)

7.2.4. Complying with Inclined Lift Regulations in a Transit Station

An inclined stairway passenger lift designed for installation in public buildings, including transit stations, would vary in size, load capacity, speed, and durability from a private lift. It would be necessary for the State Board of Elevator Regulations to modify its regulations to permit the new breed of lift. The Massachusetts regulations, for example, state in the definition of private inclined passenger lift that the device must be installed so as to be accessible only to the building occupant for whom the device was installed, and not accessible to other building occupants or to the general public.[17] (The introductory statement quoted above from the model elevator code similarly implies that the device should not be available to the general public, and should be under the control of the "head of the family.") Because an inclined lift installed in a transit station would serve many persons, an acceptable system would be needed to determine which handicapped persons may use the device, the means by which access to the device would be limited to only such persons, and the procedures by which transit operators could supervise and control the device's operations.

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(16) Id. at 159.

(17) "ELV-2 Elevator Regulations," Sec. 10.00.

One approach to this problem is contained in regulations on inclined stairway passenger lifts issued by the Pennsylvania Department of Labor and Industry.[18] Those regulations permit installation of inclined lifts in public buildings, and require key-operated continuous pressure switches at the upper and lower terminals of the lift. The Pennsylvania regulations further state: "keys shall be placed only in the hands of certain designated responsible persons and not be indiscriminately distributed, so that operation of the device can be closely supervised by a competent person at a terminal landing only."[19]

While the concept of a key-operated (or perhaps credit-card operated) switch appears sound, to require a transit operator to supply a worker to operate the lift, as suggested in the Pennsylvania regulation, would certainly add to its operating cost. The labor aspects of lift operators have not been investigated in detail. System operating costs might not be affected if underemployed workers were assigned to operate the devices. Such additional duties could appeal to workers with routine assignments who would appreciate opportunities to assist others. Added duties in connection with lift operations may be subject to collective bargaining negotiations. As an alternative, the switch could be installed on the lift platform, so that the handicapped passenger himself could operate the lift device while seated on it. To provide for the constant visual supervision required in the Pennsylvania regulations, operation of the device (or operation of all devices in a single station) could be monitored by a single employee via closed-circuit television.

Restrictive design specifications in both the Massachusetts regulations and in the model code also may limit the applicability

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[18] Commonwealth of Pennsylvania, Department of Labor and Industry, "Amended Regulations for Elevators, Escalators, Dumbwaiters, and Hoists."

[19] Id. at Rule 370.

of inclined stairway passenger lifts to transit station requirements. The Massachusetts regulations now require the lift's platform to have a seat or seats, and seat backs.[20] The lift apparently contemplated in these regulations is to accommodate ambulatory persons, not persons confined to wheelchairs. Unless the regulation were modified to permit open platforms capable of accommodating wheelchairs, a transit station operator would have to: assist each wheelchair passenger in transferring from his chair to the seat on the lift; transport the patron's wheelchair up or down the stairs and station it at the lift's destination terminal; and assist the passenger back into his wheelchair.

7.2.5 Applicability of Other Regulations

Requirements for exit stairways imposed by both elevator regulations and by public building codes constitute another impediment to the introduction of inclined stairway passenger lifts in MBTA transit stations. (This subject is treated in detail in the memorandum attached as Appendix B.) For example, the Massachusetts elevator regulations for private lifts require a minimum free-passageway width of at least 20 inches throughout the entire length of the stairway on which the lift is installed.[21] Such minimum width requirements appear to be based on the need for rapid egress from buildings in case of fire or other emergency. Public buildings, such as transit stations, are required to have a wider free exit passageway clearance of 42 inches because of the large numbers

[20] "ELV-2 Elevator Regulations," Sec. 10.00(c). The American Standard Safety Code for elevators also requires a seat, but does not mention seat back. Rule 504.3.

[21] "ELV-2 Elevator Regulations," Sec. 10.00(d). The American Standard Safety Code contains the same requirement. Rule 504.4. If the seat and platform fold automatically when not in use, the required clearnace may be measured from the folded position.

of persons expected to utilize the station.[22] Given the width of many stairways in MBTA transit stations, it would seem unlikely that inclined stairway passenger lifts could be added without violating such minimum width requirements. The likelihood of such a violation is increased if the particular lift device does not fold automatically when not in use, or if it requires a permanently installed track resting on (and permanently blocking a portion of) the stairs. Without extensive widening of stairways on which the lifts were to be installed, this requirement, unless waived or ignored, would seem an insurmountable barrier to the installation of lift devices.

7.3 STAIRCLIMBING WHEELCHAIRS

Thus far, the discussion has focused on the application of inclined stairway passenger lifts in transit stations. Another approach to be considered here is the stairclimbing wheelchair, of which some prototypes exist. No regulations or other specifically applicable provisions have been found which deal with use of externally-powered stairclimbing wheelchairs and their attendant support systems. It is assumed that such chairs would be owned by individuals who would use them to arrive at and depart from transit stations. The applicability of particular code requirements would depend on the source of power utilized. If, for example, the device relied on electric power supplied by a source at the stairway, the MBTA would presumably seek to comply with otherwise applicable electrical codes in supplying support facilities.[23] Electrical code provisions dealing with wire insulation, shielding, and wire flexibility in open, moving applications would certainly appear

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[22] Building Officials Conference of America, Inc., "BOCA Basic Building Code," Sec. 618.21. The BOCA Code had been adopted as the relevant building code for public buildings in Massachusetts by the Board of Standards in the Department of Public Safety pursuant to Mass. Gen. Laws Ann. c.143, Sec. 3B. See D.P.S. Board of Standards, Std. 10. The new state building code reduces this requirement to 42 inches. Sec. 616.21.

[23] See notes 7 and 8, supra.

relevant. To insure that all stairclimbing wheelchairs could utilize the proffered power supply, the transit operator (or perhaps a State of Federal authority) could cooperate with manufacturers of the chairs to develop a standard, compatible electrical connection mechanism. (This paper does not consider what a federal role in the design of the standardization of such devices might be.) This mechanism should be sufficiently secure so as to effectively eliminate the possibility of electrical disconnection during climbing operations. The MBTA might also request manufacturers to incorporate easily accessible electrical test circuitry in the chair to enable the MBTA to test each chair to make sure it is functioning properly before it is allowed to operate on a stairway. Such a quick-check system should reduce the chance of failures or accidental electric shocks while the device is in operation. In the absence of such a system, proof of periodic inspection by accredited inspectors or random spot checks of individuals' chairs could be required to prevent use of defective chairs with their attendant risk to both occupants and to other MBTA employees and patrons.

7.4 SAFETY IN MBTA OPERATIONS AND THE WHEELCHAIR PATRON

As indicated earlier, the MBTA is not exempt from all regulation by other state agencies. It is explicitly subjected to the jurisdiction and control of the Massachusetts Department of Public Utilities with regard to "safety of equipment and operations."[24] This limited jurisdiction is interpreted by the Department of Public Utilities to include safety matters arising out of actual operations of vehicles within the MBTA system, and not to extend to issues arising from station design or station safety.[25] Information obtained in an interview with the Deputy Director of the Rail and Bus Division with the Department of Public Utilities,[26]

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[24] Mass. Gen. Laws c.161A, Sec. 3(i).

[25] Telephone Interview with Jack McCabe, Deputy Director, Division of Rail and Bus, Massachusetts Department of Public Utilities, May 17, 1974.

[26] Id.

provided a most useful perspective on safety issues arising from the introduction of numbers of wheelchair-bound patrons on the MBTA system. At present, buses carrying wheelchair passengers must make provision for affixing each chair to the vehicle to avoid chairs being pitched about in the event of sudden stops. Similar strappings would probably be required on rail transit vehicles which accommodate wheelchair passengers. The emergency evacuation of wheelchair passengers from transit tunnels or elevated tracks poses an especially difficult problem. No provisions currently exist for evacuating wheelchair passengers from underground or elevated transit facilities in case of emergency, probably because few (if any) wheelchair-bound individuals patronize the system.[27] Current evacuation procedures call for able-bodied passengers to pass through narrow rail car doors to an end car, climb down stairs or a ladder to the track bed, walk along (and over, if necessary) the tracks and electrified third rail to an exit point, and climb a ladder to ground level. The development of adequate evacuation measures, or the accomplishment of a significant reduction in the probability of emergency, will be of major concern to the Department of Public Utilities should the number of wheelchair patrons on the MBTA increase.

7.5 TORT LIABILITY FOR INJURIES ARISING OUT OF INCLINED WHEELCHAIR LIFTS AND STAIRCLIMBING WHEELCHAIR OPERATIONS

7.5.1 Introduction

If a rail transit operator determined to make its transit stations accessible to persons in wheelchairs, that operator reasonably could be expected to identify and evaluate various means available to accomplish this goal. Such an evaluation could be

[27] It was Mr. McCabe's speculation that no provision exists for evacuating wheelchair-bound passengers from the MBTA transit system because few if any ever entered the system in the first place. While infants in carriages do ride the system, they are accompanied by able-bodied passengers who can carry them to safety in case of emergency. Id.

expected to include consideration of the relative safety of each alternative means, or, phrased slightly differently, the relative risk of harm or injury each alternative would pose both to wheelchair-bound patrons and to able-bodied transit patrons. Considerations of safety and risk of injury are relevant for several reasons: quite obviously, the rail transit operator's obligation to the public is to provide safe, as well as efficient rapid transportation.[28] Further, from a practical dollars-and-cents perspective, installation, and/or operation of a particular device to aid the handicapped did not measure up the the transit operator's legal duty to care owed handicapped and/or able-bodied patrons. Such law suits could result in a transit operator's legal liability for damages incurred by injured patrons.

7.5.2 The Carrier's Duty to Passengers

The following section of this report reviews the legal duty of care owed by a rail transit operator to its patrons, particularly those of its patrons who are disabled or physically handicapped. The report then considers the application of these principles to the operation of the two devices described in Subsections 4.3 and 4.4, the inclined stairway passenger lift and the stairclimbing wheelchair.[29] Again, this report is based on Massachusetts

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[28] See, e.g., 49 U.S.C. Sec. 1601a, declaring the findings of the Congress that expanded Federal financial aid to urban transit is imperative to achieve "efficient, safe, and convenient transportation..." (emphasis added). See also, Mass. Gen. Laws Ann. c. 161A, Sec. 5(a), stating the MBTA's "duty to develop, finance and operate the mass transportation facilities and equipment in the public interest..."

[29] This report summarizes the legal duty of care a common carrier of passengers owes its patrons. No attempt has been made to identify all the legal theories available either to an injured plaintiff or a defendant common carrier involved in a specific lawsuit. Because of the fact variations possible, it is not possible to describe the interplay of the carrier's basic legal duty and such affirmative defenses as contributory negligence, assumption of risk, last clear chance, and so on.

the body of law which would be applicable to the Boston area transit operator, the MBTA.

7.5.2.1 In General- The enabling legislation establishing the MBTA declares that the Authority "shall be liable in tort to passengers...for personal injury and for death and for damages to property in the same manner as though it were a street railway company;..."[30] In general, the duty of care a common carrier of passengers owes its patrons has been summarized as follows:

> With regard to the degree or standard of care required of a common carrier of passengers, the statement which is most frequently found in the cases is that such carriers are required to exercise the highest degree of care, vigilance, and precaution for the safety of those they undertake to transport, and are liable for injuries to passengers resulting from the slightest negligence. Some authorities have characterized the care required of a common carrier of passengers of the "utmost care and diligence" of "the utmost caution characteristic of very careful men," or have stated that a common carrier of passengers is bound to protect its passengers "as far as human care and foresight will go." Again, while it is generally held that a common carrier of passengers is not an insurer of the safety of passengers, it has been said that its duty to protect its passengers stops just short of insuring the passenger against injury. In a few cases it has been simply stated that common carriers of passengers must exercise a high degree of care, or a very high degree of care, or extraordinary care, for the safety of their passengers.

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(30) Mass. Gen. Laws Ann. c.161A, Sec. 21. Although the MBTA's tort liability is by statute expressly made comparable to that of a street railway company, the Massachusetts Supreme Judicial Court's cases do not appear to differentiate among street railways, intercity passenger railroads, and urban elevated railroads in describing passenger carriers' tort liability to passengers injured by carrier operations. For example, in Carson V. Boston Elevated Railway Co., 309 Mass. 32(1941), cited infra note 32, a case involving personal injuries arising out of operations of a street car, the court cited and relied upon an earlier decision involving an intercity passenger train (Maher v. Boston & Albany RR Co., 304 Mass. 641 (1939)), as well on other cases involving street cars.

> These differences in the statement of the care required of a common carrier of passengers are more apparent than real, the practical results attained not being materially dissimilar. It is generally agreed that a common carrier of passengers is not required to exercise the utmost degree of care which the human mind is capable of imagining or which men are capable of exercising, but rather the highest degree of paracticable care and diligence that is consistent with the mode of transportation and the normal prosecution of its business. A carrier is not required to exercise such a degree of care as will be wholly inconsistent with its methods of transportation, or impracticable to such an extent as to interface with its regular business.(31)

The duty a common carrier owes its passengers in Massachusetts has been stated by the Supreme Judicial Court as follows:

> The fundamental duty of a carrier to take care for the safety of a passenger is settled. That duty is to exercise reasonable care under the circumstances. Among those circumstances are that the carrier has control of the passenger and that consequences of negligence are likely to be serious. Accordingly, it is held that reasonable care under the circumstances is the highest degree of care,--not the highest degree of care imaginable, but the highest degree of care that is consistent with the requirements of the public for speedy and inexpensive as well as safe transportation and with the practical operation of the business. (citations omitted) Some degree of jerking, jolting and lurching being declared a necessary incident to travel, evidence of a jerk, jolt or lurch in the operation of a street car has been held not to warrant a finding of negligence, even though injury results, unless it appears to be unusual and beyond common experience. (citations omitted)(32)

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(31) 14 Am. Jr. 2d, Carriers Sec. 916 at pp. 348-350 (footnotes omitted).

(32) Carson v. Boston Elevated Railway, 309 Mass. 32 at 35-6 (1941), cited in Simpson and Alperin, Summary of Basic Law (Massachusetts Practice Series, vol. 14) Sec. 105 at 92 (1974).

7.5.2.2 Carrier's Duty Towards Handicapped Passengers - Because of the novelty of the specific devices considered in this report, quite expectedly no cases have been found discussing a transit operator's specific duty with regard to transport of handicapped persons. A few Massachusetts cases have been decided, however, which discuss the transit operator's duty toward persons with physical disabilities. In O'Leary v. Metropolitan Transit Authority, 339 Mass. 328 (1959), an action was brought against the MTA (predecessor to the MBTA) on behalf of the estate of a passenger who suffered a stroke while aboard a subway train stalled underground during a power failure. It was argued on behalf of the deceased passenger that the MTA was negligent in that its employee, the train guard, delayed in calling for help for the passenger once her condition became apparent. The court, citing an earlier decision, Silver v. N.Y. Central R.R. Co., 329 Mass. 14 (1952), stated: "We assume that the defendant (the MTA) upon notice of the passenger's condition was bound to exercise not only the high degree of care required to be exercised in respect of passengers generally, but such care as was reasonably necessary to protect the passenger in view of her condition."[33] In Silver v. N.Y. Central R.R. Co., 329 Mass. 14 (1952), cited by the court in the O'Leary v. MTA case, supra, plaintiff suffered personal injuries when a Pullman railroad car in which she had a berth was detached from the rest of a train and left standing in extremely cold weather for nearly four hours before being connected to another train. Plaintiff suffered from a circulatory ailment which had no visible manifestations but which affected blood circulation when the body is exposed to cold or to changes in temperature. The court summarized the defendant railroad's duty as follows: "Except possibly where a common carrier has, or reasonably should have, particular knowledge of a passenger's delicate condition, it is under no liability for failure to heat a car unless a person of ordinary good health would suffer harm." 329 Mass. at 18.

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[33] 339 Mass. 328 at 331. The court in O'Leary affirmed a lower court verdict for defendant MTA, finding that the MTA guard was not unreasonably dilatory.

As indicated by these decisions, the Massachusetts law appears to require that, when a carrier knows or reasonably should know of a passenger's physical handicap or other physical limitation, that carrier owes the passenger the generally required high duty of care and, in addition, such care as reasonably necessary to protect the handicapped passenger in view of his condition.

7.5.2.3 Carrier's Duty to Protect Its Passengers from Injuries Caused by Other Passengers - A wheelchair-bound MBTA passenger using either an inclined stairway passenger lift or a stairclimbing wheelchair may be susceptible to injury by the crowding, pushing and shoving of other MBTA patrons sharing the stairway right-of-way with the device. "It is settled law in this Commonwealth that a street railway company is not at fault in failing to prevent passengers from crowding as they enter or leave its cars in the customary way. This is one of the incidents of such travel and it is not of itself evidence of negligence. When there is evidence of boisterous or disorderly conduct which should have been foreseen and guarded against, the jury may find the carrier to be negligent if it failed to prevent it...." Ritchie v. Boston Elevated Railway, 238 Mass. 473 (1921). Thus, while there is no duty to protect from ordinary or "customary" crowding, the courts have recognized a duty to protect passengers from the reasonably foreseeable impacts of "boisterous" crowds.(34) In addition, as

(34) A more recent Massachusetts Supreme Judicial Court rescript opinion confirms the view that a carrier owes no duty to passengers, to protect from crowding which was not reasonably foreseeable by the carrier. The substance of the brief opinion follows:

> No negligence is shown in the circumstances that a passenger among a group boarding a trackless trolley on the front side of a dividing post shoved the plaintiff (as "he went by, hit him in the back") who was waiting behind two other passengers to descend the steps on the other side of the post; "they all kept coming up on the bus, hollering and pushing, and...(a)s they were...coming in back of him, trying to get in, pushing ...they were shoving him." The plaintiff's handicap, a paralyzed right leg, evidenced by a leg brace and cane, and known to the operator who had cautioned, "Let him out first," does not alter the result, nor does the fact that the group of eighteen persons waiting to board the bus included boys and girls with books and bags, persons who were "screaming and hollering...moving around." (citations omitted) Puzzo v. MTA 344 Mass. 756 (1962).

the language quoted in the following case indicates, this duty to protect passengers from the boisterous conduct of _expected_ crowds may be increased if a disabled passenger is involved. In _Glennen v. Boston Elevated Railway_, 207 Mass. 497 (1911), plaintiff, a woman who at the time of the accident was carrying a small child, was injured when crowds kept her from alighting from defendant's street car at the end of the line. "Evidence as to what has been the custom of a crowd at a particular place or under special circumstances in boarding the defendant's cars was competent, because a railway company has reasonable cause to know what has been habitually done respecting its cars. It bore upon the care which the defendant ought to have exercised and the protection which it ought to have furnished to its passengers who were entitled to alight even in the face of a large number of people desiring to become passengers." (citation omitted) 207 Mass. at 500. The court also noted, "It is also to be observed that the plaintiff was a woman encumbered with a small child and entitled to protection commensurate with the impaired capacity to care for herself resulting from this burden." (citation omitted) _Id._ at 500-01.

7.5.2.4 _Carrier's Duty to Protect Passengers from Acts of Vandals_ - Vandalism constitutes another potential cause of injury to handicapped persons using either an inclined stairway passenger lift or a stairclimbing wheelchair. Because of the novelty of these devices and their exposted operation on public stairways, vandals may find them inviting opportunities for tampering. In _New York, Haven & Hartford RR. Co. v. Johnson_, 263 F.2d 173 (1st cir., 1959) the Federal Court of Appeals reviewed a case applying Massachusetts law to determine a railroad's liability to its passenger for injuries caused by juvenile vandals. "...the accident occurred in an urban area, partly residential and partly commercial, where the railroad's tracks are on an embankment some 15 or 18 feet above street level,...(and where) for years the railroad had been plagued by juvenile trespassers on its right of way in the vicinity of the scene of the accident who almost daily put stones, pieces of wood, pieces of iron or other objects on its tracks." 265 F.2d at 180.

In this case, a steel cable with a hook attached had been left lying across the tracks. When the train ran over it, the hook was propelled into the side of a rail passenger car, shattering a window and injuring plaintiff. The court stated: "The case is close, but we think in view of the high degree of care required of the railroad (having previously cited Carson v. Boston Elevated Railway Co., 309 Mass. 32, supra) and its long experience with mischievous interlopers on its right-of-way through the built-up area where the accident happened, the jury could reasonably have concluded that the railroad should, and without too great burden could, have taken more precautions than it did for the safety of its passengers by fencing its main line right-of-way in the area, or by patrolling it, or perhaps by running its trains a little bit slower." Id.

7.5.3 The Common Carrier's Duty to Handicapped Passengers in Accidents Involving Inclined Stairway Passenger Lifts and Stairclimbing Wheelchairs - Applying the Case Law

The difficulty facing a transit operator evaluating the proposed installation of an inclined lift or the support facilities for stairclimbing wheelchairs lies in predicting how a jury and appellate courts will apply the principles described in the above sampling of Massachusetts common carrier liability cases to fact situations involving injuries to patrons (handicapped or not) arising out of the use of inclined lifts or stairclimbing wheelchairs. It is only possible to speculate as to what the results might be. There would seem to be no question that a transit operator would have actual knowledge of wheelchair-bound passengers' special or delicate condition. A transit operator would, therefore, be required to exercise the high degree of care reasonably necessary (cf. the O'Leary opinion) to protect such passengers in view of their special circumstances.

Given the relative helplessness of a wheelchair-bound patron aboard a moving inclined lift or a moving stairclimbing wheelchair in the event of slippage or rolling off the lift platform, coupled with the accident-precipitating ingredients of crowds, especially foreseeably large and/or boisterous crowds, and the possibility

that vandals will interfere with either device's operation, it would seem that a jury could conclude that the use of either device was negligent. For example, even the customary crowds which foreseeably occur at daily peak hours might interfere with operation of an inclined stairway lift or stairclimbing wheelchair. Again, it is impossible to predict whether a transit operator would be held liable for failure to take measures to protect wheelchair-bound passengers against such risks as posed by ordinary but foreseeable crowds.[35] Given this uncertain state of the law, a transit operator might consider it necessary to install elaborate safety backup systems. The precautions identified in the Johnson opinion to protect against vandals - fencing and patrols - also could be required of transit operators wherever lifts or stairclimbing wheelchairs are used. Measures taken to protect against such risks, including perhaps the fencing of stairway rights-of-way to prevent interference with either device's operation, the use of attendants or closed-circuit television to monitor and assist handicapped passenger's stairway movements, or other precautions, may make such devices financially or otherwise unacceptable.

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[35] In this regard, however, the language in the Glennen case, cited earlier, may foreshadow developments in the law in this area. In that case, involving a crowd's pushing a woman "encumbered with a small child," the court made mention of the carrier's duty to provide "protection commensurate with the impaired capacity."

8. CONCLUSIONS AND RECOMMENDATIONS

Within the framework of this study some serious issues have been raised and in so doing, areas for future investigation have been identified. These issues are summarized below. Some of these issues are directly related to vertical movement problems, while others are germane to the integration of the handicapped and elderly into the public transportation system.

Study conclusion issues are as follows:

Market Analysis/Needs Assessment - Data on the handicapped (H/E) market by functional limitations, mobility limitations and travel needs across specific categories of the H/E market are insufficient in detail and numbers, as well as inadequate in depth for designers and planners to intelligently solve this group's unique transportation needs.

Transit Facilities Assessment - The unique architectural character of older facilities creates unusual and individualized access/egress problems both in terms of handicapped/elderly utilization and vertical movement device implementation. Hence, the device option which is technically most effective for a given station, depends on detailed architectural evaluation of the individual station under consideration.

Cost Evaluation - Cost data shows that the non-standard vertical movement devices are considerably less costly than an elevator or conveyor system. Elevators similarly are less costly by a slight margin than conveyor devices.

Device Utilization Evaluation

Elevator systems - Vertical and inclined elevators provide a high degree of performance capabilities in various H/E classifications. Although the inclined elevator is more expensive than the vertical elevator it does offer the advantage that it can be combined

with existing escalators, thereby better integrating traffic flows. It needs little technological development or additional assessment to meet user requirements. The vertical elevator is, of course, readily available.

Conveyor Systems - Escalators and moving inclined ramps are not viable alternatives for providing vertical movement to the handicapped and elderly since many dysfunctions experienced by the handicapped and elderly are incompatible with the mechanical operation of these devices. Even if these devices were provided with user activated stop/start adoptions, usability would not be assured.

Non-Standard Devices - Of the non-standard devices evaluated, (i.e., the stairclimbing wheelchair and the inclined stairlift) the inclined stairlift has the greater potential for providing vertical movement capability for a wide range of handicapped dysfunctions.

However, the inclined stairlift, while attractive from a capital cost viewpoint, requires analysis and engineering development to produce a unit for public buildings which can provide safety to both the user and non-user. Such a unit could offer service to a wide range of handicapped persons in situations where other alternatives would prove too expensive. Building codes may constitute an impediment to the installation of inclined stairway passenger lifts in transit stations. Even assuming technical compliance with existing or changed elevator regulations and building codes, achieving designs providing safety in both routine and emergency operations is a substantional undertaking and should not be lightly dismissed.

Compliance with regulations may not suffice to exempt a transit operator from liability for passengers' injuries if legal judgments conclude that the mere operation of such devices in crowded transit stations constitutes negligence. As stated in Section 7, the outcome of such litigation cannot be predicted with

certainty. To protect its patrons and itself, a transit operator considering the installation and use of these devices must develop adequate safety programs governing all aspects of use.

In summary given the aforementioned issues only the elevator systems can be readily implemented in the near term. Use of the inclined lift while promising from a capital cost viewpoint requires analyses and development to attempt to satisfactorily resolve the safety and the regulatory code issues.

APPENDIX A

VERTICAL MOVEMENT DEVICE - COST STUDY BACK-UP DATA

A.1 INTRODUCTION

The major cost in providing access to public rapid rail transportation for the handicapped and elderly is that of acquiring and installing vertical movement devices in transit stations for patrons unable to use regular stairways or escalators.

This appendix presents cost estimates for each major type of vertical movement device (i.e. elevators, stairlifts, etc.) as well as the costs of facilities modifications and/or reconstructions that would be necessary to install these devices in existing or planned transit stations.

In the preparation of these cost estimates, the plans of the Washington Metropolitan Area Transit Authority (WMATA) and the Bay Area Rapid Transit (BART) systems were thoroughly analyzed. In addition, equipment manufacturers estimates, General Service Administration (GSA) guidelines and standard building and cost estimating guides were used in preparation of these estimates.

The estimated costs shown in Table 1-8 through 1-11 reflect a broad span of factors which must be considered in the selection, procurement and installation of vertical movement devices in an existing or proposed transit system. Land and operating costs were not considered. Fare collection equipment was considered as a total system cost and not a direct cost in installing vertical movement devices in a transit system.

A.2 ELEVATOR SURFACE ENTRANCES

Surface entrance costs are applicable to all types of elevator devices. Where devices interface the street, it was deemed necessary to protect both the vertical movement devices and their users from ambient environmental conditions.

The elevator surface entrance and overrun space is assumed to be 3,600 cubic feet (CF) (reference 1). The unit cost for the structure to enclose this space is estimated at $5.60 per cubic foot. Thus, the surface entrance cost for vertical or inclined elevators would be: 3600 CF x $5.60/CF = $20,160.

A.3 CONTRACTOR MOBILIZATION COSTS

The costs are included under all entries where transit station construction, modification and/or demolition activities are required.

A.4 UNIT INSTALLATION COSTS ASSUMED IN VERTICAL MOVEMENT DEVICES STUDY

Unit installation cost is the manufacturers' base cost per unit device installed, plus costs for device adaption and/or alterations in the basic design, such as providing vertical rises differing from standard models.

A.4.1 Elevator Equipment - Vertical Elevator Installations

In vertical elevator installations, two types of elevation devices are feasible; the hydraulic and the electric. Hydraulic elevators will be used in lifts up to 50 feet, electric elevators for lifts above 50 feet.

In most electric elevator installations an underslung arrangement is planned whereby the machine room would be located at a level lower than the top of the elevator hoistway (reference 2). Therefore, because of the street height requirements as prescribed in the WMATA study, this study assumes all electric elevators to be underslung. The assumption is conservative since underslung elevators are more costly than standard traction elevators employing overhead machine room (reference 3).

All elevators are assumed to have a 2,000 pound capacity. Hydraulic elevators are assumed to have a speed of 75 feet per minute, and electric elevators a maximum speed of 250 feet per minute. While the specifications only recommend 150 feet per

minute, this higher speed and consequent use of electric elevators has been recommended for deeper stations.

A.4.1.1 Hydraulic Elevator Installation Costs - The basic cost for a low rise, two stop hydraulic elevator (including installation) ranges from 20,500 to 25,000 (1974 dollars) (references 2,4,5, and 6).

This study assumes:

- Hydraulic elevators (each installation)	
- Elevator equipment and installation (Base Cost Two Stop)	$25,000
- Allowance for special cab, remote location control and electric eye doors	15,500
Total cost per hydraulic elevator installation	$40,500

A.4.1.2 Electric Elevator Installation Costs - The basic cost of a two-stop electric elevator is estimated to be $35,000 for a 100-foot rise at 150 feet/minute and $40,000 for a 150-foot rise at 250 feet/minute (reference 2,3,5, and 6).

This study assumes:

Electric elevator (each installation) base cost of elevator equipment and installation	$40,000
Allowance for special cab, remote location control and electric eye doors	15,500
Total cost per electrical elevator installation	$55,500

A.4.2 Inclined Moving Ramp

This ramp is a specialized form of conveyor. This study assumes a 36-inch wide ramp with a speed of 90 fpm and in incline of 15° for a height of 12 feet.

The Base Cost of the Ramp per installation (12 feet, 15°)	$75,000
Added cost per 10 foot length is $5,000 x 3 Lengths*	15,000
Total cost of inclined moving ramp installation	$90,000

*Three additional ten foot lengths are required to raise the ramp lift height to fifteen feet.

A.4.3 Stairclimbing Wheelchair

Base Cost per unit motorized	$ 2,800
Per unit non-motorized	$ 1,700

This estimate is based on conferences with manufacturers and their representatives and it averages cost figures for several manufacturers' schemes (reference 7).

A.4.4 Inclined Stairlift

At present, the installation cost of an inclined stairlift per unit per stairway flight ranges from $3,200 to $6,200 (reference 8).

Thus, the estimated installation cost breakdown for this unit is:

Base Cost per stairway flight	$ 6,200
Additional tooling special, cabling, remote location control	1,750
Allowance for stairway landings	560
Allowance for cornering	560
Total cost for inclined stairlift installation	$ 9,070

Since most stations are two (2) stories deep, one landing is usually encountered, therefore, an allowance for an extra flight:

	$ 9,070
	$ 6,200
Total (per installation)	$15,270

Thus, an associative cost for a comparable and compatible system is similarly computed. Thus, the overall total cost of an up/down system:

	15,270 x 2
Total	$30,540

An additional allowance of four to five percent must be allocated per unit installation per base cost per year:

$30,540 x 4.5% = $ 1,374

A.4.5 Escalators

The basic cost of an escalator with speeds ranging between 90 to 120 feet per minute and a carrying capacity of 5,000 to 8,000 people per hour varies from $44,000 to $74,000. This study assumes the larger capacity speed for the excessive volumes of people using mass transit. Since $74,000 is a standard cost (associated with a 12 foot rise), this study assumes an $89,000 cost figure to more accurately reflect the 15 foot plus rises used in most rapid rail system facilities.

This $89,000 figure was arrived at as follows:

Base Cost of escalator per installation 32-inch wide single type (per 12 foot story)	$74,000
Cost for each additional foot (above 12 feet) 3 feet x $5,000/foot	$15,000
Total cost per escalator installation	$89,000

A.4.6 Broadstep (Wheelchair) Escalator

The estimated production cost of a broadstep (or wheelchair) escalator after research and development would be approximately 2 to 2 1/2 times the cost value of a conventional escalator for the same length of travel.

The estimate assumed is:

Base Cost of broadstep escalator equipment and equipment and installation	$192,750
Selective manual self start/stop mechanism with automatic self leveling dual control remote operation	$ 7,500
Additional Allowance for extra rise per foot 3 Feet x $7,500/Foot	$ 21,500
Optional features electric eye edge guards, self leveling guard rails	$ 1,500
Total cost for broadstep (wheelchair) escalator installation	$223,250

A.4.7 Inclined Elevators

One elevator manufacturer has estimated the cost of inclined elevators to be two times the cost of conventional equipment for the same length of travel (reference 9). They estimate a unit cost of 96,000 each for runs of the order of 30 feet. The estimate assumed in this study is:

Base Cost of inclined elevator equipment and installation	$48,000 x 2 =	$96,000
Allowance for remote operation, special cabs, electric eye doors		$15,500
Total cost per installation		$111,500

A.5 EXCAVATION/SHAFT CONSTRUCTION

These costs are associated with vertical movement devices which require excavation work, such as new elevator shafts or enlarging existing openings to accommodate conveyor systems requiring different slopes such as the inclined moving. When non-standard vertical movement devices can be accommodated by existing transit station stairways, there are no associated shaft construction costs estimated.

For costing purposes, all shafts and tunnels are assumed, to be excavated since individual excavation is more costly than other construction methods. Costs will be presented on the experiences of the BART and WMATA studies, since the accuracy of book estimating is guess work due to labor, equipment and inflation. The stations, BART excavation and lining cost averaged $65 per cubic yard for cut and cover and $200 per cubic yard for tunneling (1964-1971 dollars). In difficult ground, some BART unit costs exceeded $500 per cubic yard (reference 11). Early WMATA estimates indicate costs of $200 - $400 per cubic yard (reference 12).

This study assumes unit costs for excavation in competent rock and lining will be $260 per cubic yard. Since sharing costs for earth and loose rock excavation are higher than for competent rock, excavation of earth and loose rock was estimated to be $350 per cubic yard. The aforementioned costs are for inclined elevator shafts which are enlargements of shafts which already have a substantial cross sectional area. To estimate the unit costs for vertical elevator shafts, the above unit costs would have to be doubled because the relatively small cross section can be expected to have a substantially higher unit cost.

This study used the following unit costs for elevator shaft and tunnel excavation, lining and finishing based on references 11, 12 and 13.

Vertical Shafts	
Rock	$2,000/Foot
Loose rock and earth	$2,500/Foot
Inclined Shafts	
Rock	$ 664/Foot
Loose rock and earth	$1,000/Foot

A.6 DEMOLITION/STRUCTURAL MODIFICATION

Demolition/Structural Modification costs are estimated for the elevator and conveyor systems only, because these devices will require some structural alterations in order to install them

adjoining existing stairways, or in new transit station locations. Non-standard devices can be integrated into existing stairways without extensive structural modifications.

In renovating older stations, a certain amount of demolition of existing station structures and structural support members is assumed. The study estimates the cost of these items to be: (reference 4)

Elevator Installations - Demolition of "existing" structures and structural modification: $1,900/Elevator

Inclined Elevator Installations - Demolition of "existing" structures and structural modification $ 32/Foot (along shaft)

A.7 ELEVATOR EQUIPMENT ROOM

Equipment Room Costs are determined as a function of required pit space for installation of elevators. Operating and control mechanisms are installed within non-standard and conveyor devices and therefore these devices do not require pit space.

Using a unit cost of $450 per cubic yard (CY) of net excavation, the study estimates the cost of these equipment rooms to be:

Electric elevator equipment rooms $450/CY x 30 CY = $13,500/Elevator

Hydraulic and inclined elevators 5,600/Elevator

A.8 ENCLOSURES

The use of elevator enclosures that have a maximum transparency are recommended. These are assumed to be structural steel frames covered with tinted glass panels. Enclosure costs were applied to all devices. Existing building codes mandate enclosures for elevators. Since building code requirements for non-standard devices are considered to be a probable eventaulity, they too were costed out.

The basic unit costs are as follows:

Glass work	\$ 11.50 Square/Foot
Steel work	\$900.00 Erected/Ton

Vertical Installations (per elevator)

Steel framed glassed wall enclosure	\$530/Foot of Rise
Foundations, Enclosure, Overrun	\$8,000 Installation

For inclined elevators, the enclosures are composed of two end enclosures plus a glass wall from balustrade height to ceiling along the hoistway from mezzanine to surface application.

Three inclined Installations (per elevator)

Mezzanine to Surface	\$ 112/Foot of Slope
Mezzanine to Platform	\$ 280/Foot of Slope
Foundations and Enclosures	\$8,000/Installation

A.9 POWER INSTALLATION

Power Installations costs are associated with rerouting power lines when installing a particular vertical movement device. Since most devices would either operate within or next to existing staircases where power is presently available, only vertical elevators were assumed to incur this cost. A power installation allowance of \$1,200 per vertical elevator was allowed for routing power cables to the elevator machine room.

A.10 SURVEILLANCE EQUIPMENT

Surveillance equipment costs were applied when vertical movement device entry/exit locations were not in the main flow of public traffic. Only vertical elevator systems are affected since vertical elevators cannot be located within or contiguous to existing stairways which are the primary conduits of station pedestrian traffic.

Where elevators are used, but are not located within full view of the general public, the security and safety of all handicapped and elderly patrons will have to be observed. This will be accomplished by a closed circuit television system monitored by the

station attendant. Three camera installations have been recommended, one at each entrance and one in the elevator cab.

The unit cost of a television monitor set is estimated to be $1,200. An allowance of $600.00 is estimated for wiring each camera.

Total Surveillance Equipment Costs	$5,400/Elevator

A.11 SPECIAL SIGNS

Special signs will be required in and around transit stations to direct the handicapped and elderly population to the available vertical movement devices.

The cost of such signs will be:	$1,200/Station

A.12 SNOW MELTING EQUIPMENT

WMATA plans to provide electrically heated areas in front of all station entrances to melt accumulations of ice and snow (reference 2). It is estimated that in 1974 dollars the cost of snow melting coils will be $560/station entrance.

A.13 FARE COLLECTION EQUIPMENT

At present, the only references to fare collection equipment that accommodate the needs of the handicapped are those being used by BART, and which WMATA has also adopted. The cost experience of this equipment is:

Fare Gate (2 way)	$46,000
Additional Fare Machine	30,100
Ticket Vendor	32,400
Change Machine	25,000
Total	$133,500

With engineering and installation costs, it is estimated that $290,000 will be required per installation. The above unit costs have been adjusted to 1974 dollars using the Engineering News Record Construction (references 10 and 11).

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APPENDIX B*

THE EFFECT OF BUILDING CODE REQUIREMENTS FOR EMERGENCY EGRESS ON INCLINED STAIRWAY INSTALLATIONS IN PUBLIC BUILDINGS

Egress requirements imposed by public building codes constitute an impediment to introduction of inclined stairway passenger lifts into MBTA transit stations. Minimum standards for the location, number and capacity of exit stairways are prescribed by both the 1970 BOCA Basic Building Code (hereinafter referred to as BOCA) and the National Fire Protection Associations's Building Exits Code (hereinafter referred to as Exits Code). Both codes develop a set of criteria for establishing the egress requirements of diverse building types. Although the MBTA need not observe the two codes, a review of the codes' essential egress requirements, particularly as they relate to transit stations, reveals important considerations about the applicability and practicability of inclined lifts in mass transit use.

The type of egress facilities required in a building depends on the interplay of two factors: The probability of emergency situations posed by the activity within the building and the expected number of occupants which the activity attracts or utilizes. Thus, the codes establish use group categories and prescribe occupant density (Occupancy Load) in an effort to meet a particular structure's expected egress requirements.

Passenger terminals are "Use Group F-3" structures, a subcategory of "Assembly Buildings" (BOCA Para. 208.3). According to the Exits Code, the expected occupancy load of passenger terminals is one person per three square feet of net floor area (Exits Code Para. 2104). Since the number of exits required depends on the capacity of a particular structure, transit station capacity is

*This appendix was prepared by Gabor Garai, a summer law intern with the Transportation Systems Center.

determined by the size of the station's standing area as a function of the prescribed occupancy load (Exits Code Para. 2111).

For example, an average MBTA transit station with a platform length of 300 feet and width of 12 feet (3,600 sq. feet) can accommodate 1,200 occupants according to the Exits Code formula. Such a station is classified as a Class A capacity structure (capacity of over 1,000 occupants); a somewhat smaller station, with a standing area designed to accommodate less than 1,000 people (capacity of between 200 and 1,000 occupants), is considered a Class B structure. According to the Exits Code, Class A buildings require a minimum of four exits and Class B structures of over 600 capacity require at least three exits (Exits Code Para. 2111). Therefore, if Exits Code standards were to apply, the average MBTA station mentioned above would require a minimum of four exits.

The Exits Code requirements for minimum number of exits in passenger terminals are based on estimated maximum capacity. This capacity is derived from actual station size, multiplied by the expected occupancy load (number of persons per square foot of passenger area). MBTA occupancy estimates indicate that current passenger traffic never reaches the maximum occupancy load; an average MBTA transit station with a 3,600 sq. foot platform area accomodates no more than 700 patrons at one time during any peak period. Thus, the maximum station capacity, as estimated by the Exits Code, is reached and the number of exits needed to evacuate the current peak passenger load may be reduced from the Exits Code requirement of four exits to three. Presently, the average MBTA station has two stairway exits, with the train tunnels serving as an additional means of egress.*

BOCA and Exits Code requirements also establish the minimum total width of exit stairways in passenger terminals. In determining this width, two capacity estimates are crucial: the maximum number of passengers in the station at one time and the number of people able to pass through a stairway of a given width per minute.

*Estimates by Mr. John Williams of the MBTA

Once these two factors are known, it is easy to determine the minimum stairway width necessary to evacuate, in a given amount of time, all of the people in the station.

Exits Code and MBTA estimates of the maximum passenger load of an average MBTA station have already been elaborated. Estimates of exit stairway capacity, however, remain to be explored. Here again, the Exits Code and MBTA estimates slightly diverge. BOCA has elaborated a system of "Exit Width Units" which specify exit capacity. According to BOCA, each Exit Width Unit of 22 inches accommodates sixty people per minute, with twelve inches, or one-half Exit Width Unit, accommodating one-half of the above number in assembly buildings (Table 12, Page 131). The Exits Code adapts BOCA's Exit Width Unit measurement and established minimum exit width requirements in terms of the BOCA width standard. For passenger stations, the Exit Code requires "means of egress sufficient to provide one unit of exit width for each 100 person capacity of platform area (3 sq. feet per person as per Para. 2104), not counting the loading side of the platform as a means of egress if elevated more than one foot above the track or roadway grade" (Exits Code's maximum estimated capacity figures, the aforementioned MBTA passenger terminal will need a total minimum stairway exit width of twelve Exit Width Units (22 feet) or an average of three width units (66 inches) for each of the four stairways required by the Exits Code. This minimum stairway capacity would allow the estimated 1,200 passengers to pass through the exits in one and two-thirds minutes.

The MBTA exit capacity estimates vary from the BOCA Exit Width Unit Standards. According to MBTA calculations, each foot of stairway width accommodates twenty people per minute. Using this figure and the MBTA station capacity estimate quoted above (700 passengers), the same statinn would require a total exit width of 21 feet, or an average width of 7 feet for three stairways, in order to evacuate the terminal in the same one and two-thirds minutes' time. In any case, however, each stairway must have a minimum of two width units (44 inches) capacity -- the minimum width requirement for interior stairways prescribed by BOCA (BOCA Para.

618.2). MBTA guidelines call, in fact, for a minimum of four feet per stairway, with a preferred stairway width of six feet.**

The possibility of the installation of an inclined lift in a particular subway station depends, therefore, on the above minimum exit number and width requirements of stairwells. In addition, if the Exits Code specification is followed, the total length of travel from any point to reach an exit stairway must not exceed 100 feet in any place of assembly, such as a transit station, where the principal floor is more than 21 inches above or below grade at the point of principal entrance (Exits Code Para. 2114).

The general conclusion drawn from the examination of the above code restrictions indicate severe limitations in the applicability of inclined lifts in public buildings, and especially transit stations. The partial use of a stairway can be allowed only if its installation does not restrict the individual stairway's effective width below the minimum forty-four inches and does not decrease the total exit width of the facility below the code requirement. Since the Exits Code requires the measurement of effective stairway width from the narrowest point and prohibits the swinging of doors (and presumably other objects) into the measured effective width of the passageway, even an inclined elevator with folding capability would narrow the effective width of the stairway by the amount of the lift's width in the open position (Exits Code Para. 3012 and 3122). In addition, the Exit Code's access requirement might preclude the closing down of a stairway even if the egress number and width requirements were met; the remaining stairs might be outside of the 100 feet range specified by the Exits Code (Exits Code Para. 2114).

The Exits Code labels all protruding objects extending into a corridor on a stairway as dangerous and undesirable (Exits Code Para. 3121). The operation of an inclined lift in an open stairway might fit into this category. The enclosure of the inclined lift's path of travel and the installation of elevator-type doors,

**Per conversation with Mr. John Williams of the Massachusetts Bay Transportation Authority (MBTA).

however, poses difficulties in the lift's ability to conform to both the construction requirements of BOCA and the standards of the National Elevator Code.

Since adherence to the basic principles of both of the above codes is the avowed policy of the MBTA and other transit authorities, these difficulties will have to be resolved if the utilization of inclined lifts in transit stations is to be made possible.

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